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VOLUME 15 JULY, 1941 NUMBER 4

THE FAUNA OF THE PASCAGOULA FORMATION

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Lafayette, Louisiana

ABSTRACT—The Pascagoula formation has been assigned to various horizons in the geological column and this paper is an attempt to establish its age by the use of paleontologic evidence. A review of the literature pertaining to the formation is given. The formation is found to represent in part a brackish water phase of the *Arca* zone of the Choctawatchee of the middle Miocene. Six new species are described; two are assigned to the ostracode genus *Anomocytheridea*, one to *Cytherura*, one to *Microcythere*, one to *Cytheromorpha*, and one to the pelecypod genus *Ostrea*. A checklist is included to show the occurrence of the fauna.

INTRODUCTION

PASCAGOULA has been used for nearly a half century as a geologic name and during that time it has been referred to various places in the geological column, probably with reference to more than one lithologic unit. It is the object of this paper to summarize the present status of the Pascagoula formation, to review its fauna so that it may be recognized in areas other than the type locality, and by paleontological evidence, to determine its place in the standard column.

Pascagoula, in geologic usage, first came into print in a paper published in 1893 by L. C. Johnson. While working with the Alabama Geological Survey Johnson went west into Mississippi to search for instructive outcrops of late Tertiary formations. In this paper, which was preliminary to a report for the Alabama Geological Survey, he discussed the various phases of the Grand Gulf[1] strata:

> A fourth (phase) manifests itself below Leaksville on the Chickasawhay, on the Lower Leaf River and Pascagoula—being clays of more tenacious quality—abounding in specks and nodules of calcareous material, and in a few places holding shells of mollusks. One locality of the last, where first discovered, is Shell Landing below Roberts' Bluff, four miles south west of Vernal postoffice. This is the Pascagoula phase or formation.

In 1894, Smith mentioned Johnson's dis covery of the Pascagoula and considered i to be upper Miocene.

In a later report by Smith, Johnson and Langdon (1894, pp. 93–97), Johnson gave

[1] Grand Gulf was first used as a name for sandstone beds exposed along the Mississippi river near Grand Gulf, Claiborne County, Mississippi by Wailes who was the first state geologist of Mississippi. Wailes (1854, pp. 216–219) referred to the beds as "Grand Gulf sandstones." Hilgard (1860, pp. 149–193) later used the name "Grand Gulf group" for beds exposed between Vicksburg and the relatively recent (Port Hudson) clays nearer the coast. Other writers have used the name with various shades of meaning. In view of the confusion, Veatch (1906, pp. 42–43) substituted the name "Catahoula formation," from Catahoula Parish, Louisiana, which is directly across the Mississippi Valley from Grand Gulf and where many beds are exposed that are lithologically and stratigraphically counterparts of those of the old type locality. Since 1906, most authors have used the name Catahoula for the basal, sandy part of the Miocene series which had previously been termed Grand Gulf; the younger portions being termed Hattiesburg and Pascagoula.

the Pascagoula the rank of formation named for one of the rivers on which it outcrops. These beds were no longer considered to be a phase of the Grand Gulf sequence because

> . . . though retaining the same general color and appearance and manner of stratification are quite different really in material, and possibly in method of genesis. A portion of these south eastern layers have also been found to contain marine or rather estuarine fossils; this alone must separate it from the great north western beds of fresh water quartzites and clayey sands.

Several exposures were mentioned by Johnson and two sections were given, but they are of little use now since the local place-names by which he located them are changed.

In a short description of the Tertiary formations of Mississippi in 1906 by Crider and Johnson[2] (p. 11), the Pascagoula is placed immediately above the Vicksburg and below the Grand Gulf. In discussing brackish water deposits in Texas, Deussen (1914; pl. I) placed Kennedy's Fleming clay (Kennedy, 1892, pp. 62–63) above the Catahoula, both of which he considered Oligocene in age. Later in the same paper (pp. 72–74), with a note to the discrepancy, Deussen placed the Fleming in the Miocene. Some of Deussen's Fleming localities were later correlated with the Pascagoula by Matson (1916, p. 225), who gave the following discussion and redefinition of what he termed the Pascagoula clay:

> A series of blue, green, and grey clays, locally calcareous, with interbedded sands and more rarely sandstone, lying unconformably above the Hattiesburg clay, has been called the Pascagoula clay. This formation is locally fossiliferous and has furnished remains of marine or brackish-water invertebrates at Shell Bluff and Givens Landing, on Chickasawhay river, Miss., and in numerous wells in the southern part of the State. A somewhat different fauna has been obtained from the formation at Pine Prairie and southwest of Alexandria, La., and at Burkeville, Tex. The formation ranges in thickness from about 250 feet in Alabama to 450 feet near Mississippi river in Louisiana and along the Gulf coast in Mississippi. In western Louisiana and eastern Texas the thickness has not been accurately determined but it is thought to be about 250 or 300 feet. Local variations in thickness are to be expected, because the Pascagoula clay is overlain unconfromably by sands and clays of Pliocene age and rests unconformably on the Hattiesburg clay.

[2] This particular part of the paper does not seem to have been written by Johnson.

The Pascagoula clay differs from Johnson's Pascagoula phase or formation by including a portion of his Fort Adams or Ellisville phase extending from Tunica, La., to Columbia, Miss. The type locality is, however, the same, and the difference is largely due to a more thorough understanding of the formation. West of Mississippi river the Pascagoula clay extends across southern Louisiana and eastern Texas and includes the upper portion of what Veatch called the Fleming clay.

A year later, Matson (1917) published a geologic map of Louisiana showing the distribution of the beds he considered to comprise the Pascagoula clay and stated that the Miocene series contains a single formation, the Pascagoula clay.

The faunas from near Alexandria, Louisiana, Pine Prairie and Burkeville, Texas, mentioned above by Matson, were described by Dall (1913). Dall did not correlate these fossils with the Pascagoula but with fossils collected at an exposure on the Satilla River in Georgia. He considered them to be Pliocene in age. *Potamides matsoni* is a characteristic fossil at the above localities in Texas and Louisiana, and along with associated microfossils it has been used extensively for subsurface correlation in the coastal region of these states. The beds carrying these fossils are commonly known as the "*Potamides matsoni* zone." Some of the Foraminifera and Ostracoda of this zone have been described by Stephenson (1935) from the locality southwest of Alexandria. In the same paper Stephenson (pp. 187–188) pointed out that

> In as much as *Rangia johnsoni* is normally encountered in wells several hundred feet before *Potamides matsoni* is reached, it is apparent that there is considerable difficulty in considering the former to be upper Miocene and the latter to be lower Pliocene.

Nearly all the men who have written about the Pascagoula have stated that it is separated from the Hattiesburg below, and the sand and gravel above, by unconformities, but none of them mentioned any place where the lower unconformity may be seen. In the present investigation no such unconformity was found separating the Pascagoula from beds below, but the Pascagoula beds at the type locality and other exposures are overlain unconformably by sand and gravel.

Due to the estuarine character of the

Pascagoula formation, the fossiliferous beds occur in the form of lenses. Since the sediments are so similar to those of the underlying Hattiesburg, the formation is difficult to map. Its thickness is even more difficult to determine. The thickness has, however, been variously estimated to be from 200 feet to over 1000 feet (Matson, 1916, p. 225; Lowe, 1919, p. 94; Lowe, 1925, p. 76; Brantley, 1920, pp. 169–170; Morse, 1934, pp. 12–13; Stephenson, Logan, and Waring, 1928, p. 57, p. 228; Semmes, 1929, p. 283; Howe, 1933, pp. 643–648; Lowe, 1919, pp. 51–52). The greater thicknesses were estimated from well logs and of course the formation should be expected to thicken down dip.

The age of the Pascagoula has been given by some writers as embracing the whole of the Miocene epoch (Matson, 1917, p. 148, p. 151, and 1916, chart facing p. 172; Howe, 1919, p. 94, and 1925, p. 76; Brantley, 1920, fig. 23, pp. 169–170) and by others as only a part of the Miocene (Morse, 1934, pp. 12–13; Morse, 1935, p. 9, and 1936, p. 9; Stephenson, Logan, and Waring 1928, p. 228, pp. 57–58; Semmes, 1929, p. 283; Howe, 1933, pp. 643–648).

In showing that *Rangia johnsoni* and the "*Potamides matsoni* zone" ostracode assemblage occur as lenses both above and below marker fossils of the *Arca* zone of the middle Miocene of Florida (Cushman, 1930 and 1932), Howe and McGuirt (1936, p. 234) note also that

> The occurrence of *Rangia johnsoni* and the "*Potamides matsoni* zone" ostracode assemblage of *Cytheridea matsoni*, *Cytheridea* cf. *locketti*, and *Microcythere moresiana* associated together in cores from the Cockrell-Moran no. 23 well (Lake Washington dome in Plaquemines Parish) at depths of 4492–4497 and 4497–4502 feet is likewise of interest.

After examining material from the type locality of the Pascagoula, Howe and McGuirt are convinced that *Cytheridea* cf. *locketti* is not *Cytheridea locketti* Stephenson but is a different form, *Anomocytheridea pascagoulaensis* later described in this paper, thus making the above fauna that of the Pascagoula and not of the "*Potamides matsoni* zone." The presence of *Microcythere johnsoni*, n. sp., in the cores also confirms this fact. Therefore, since the full range of *Rangia johnsoni* is not known at present, it seems safe to say that the Pascagoula formation, the "*Rangia johnsoni* zone" as it is often called, represents at least a brackish water phase of the marine *Arca* zone of the Choctawhatchee of middle Miocene.

The field work upon which this paper is based was done during a three day trip into South Mississippi in December of 1938 with Dr. C. J. Roy, instructor in economic geology at Louisiana State University, who had been in the area before. Robert Welch and Robert Bridges, students in geology at Louisiana State University assisted in the field.

The writer is indebted to Dr. H. V. Howe, Director of the School of Geology, Louisiana State University, for his help in identification of the fossils and in preparation of the manuscript. Mr. J. Frank West, paleontologist, Shell Petroleum Corporation, Houston, Texas donated material collected by him from the area of outcrop. R. J. Monaghan, student in geology, Louisiana State University, assisted in figuring fossil specimens. Dr. W. C. Morse, state geologist of Mississippi, donated maps that were used in the field.

SECTIONS

On a recent visit to the area of the Leaf, Chickasawhay and Pascagoula rivers, two important exposures of Pascagoula were seen. One section, exposed at Shell Bluff, appears to be the type section of previous publications. Though the section is said to be on Pascagoula river, it is actually on Chickasawhay river. The exposure about one half mile below Miller's Bridge[3] on the Chickasawhay is much the better of the two, but it does not contain the bed of *Ostrea westi*, n. sp. At this locality, the writer found a poorly preserved fossil gar.

Section at Shell Bluff on left bank of Chickasaway River.

(Center SE ¼, sec. 28, T. 1 N., R. 7 W., Green County, Mississippi.)

[3] Miller's Bridge has been used as a crossing for a local road over Chickasawhay River but at the present time a new bridge is under construction for a new route of Mississippi highway 15 at the same site. In the future, if the name Miller's Bridge is abandoned, the place may still be easily located.

	Feet
Cover of sand and gravel	10±
Brown silty clay, with many internal and external molds of pelecypods, all calcareous material leached out	2
Light bluish grey sandy marl, with many *Rangia johnsoni*, and *Ostrea westi*, n. sp.	1
Light bluish grey sandy marl, with many *Rangia johnsoni* and fragments of larger shells, to river level at low stage	2
Light bluish grey sandy clay, with few shell fragments, and streaks of bright blue to bottom of auger hole	20

Section on right bank of Chickasawhay River one half mile below Miller's Bridge.

(SE corner SW ¼, sec. 29, T. 1 N., R. 7 W., Green County, Mississippi.)

	Feet
Cover of sand and gravel	20±
Greenish grey sandy clay, unfossiliferous	20
Buff colored, massive, sandy clay, with scattered shell fragments, calcareous nodules and carbonized material	3
Light grey, very friable coquina-limestone, largely of shell fragments, with microscopic calcite crystals, forming top of low vertical bluff	2
Grey clayey silt, few small calcareous nodules, many shell fragments, poorly bedded, contained fossil gar	1
Bluish grey silty clay, with few shell fragments	1½
Yellowish grey silty clay, to river level at low water stage	1

LOCALITIES AND SAMPLES

Locality 1.—Shell Bluff on right bank of Chickasawhay River (center SE ¼, sec. 28, T. 1 N., R. 7 W., Green County, Miss.).

Sample	Feet above or below water level
1	2
2	1
3	− 1
4	− 2
5	− 4
6	− 6
7	− 8
8	−10
9	−12
10	−14
11	−16
12	−20

Locality 2.—Bluff ½ mi. below Miller's Bridge, on right bank of Chickasawhay River (SE cor., SW ¼, sec. 29, T. 1 N., R. 7 W., Green County, Miss.).

Sample	Feet above water level
13	9
14	4
15	3
16	2
17	Water level.

Locality 3.—Bluff ½ mi. above Miller's Bridge, on right bank of Chickasawhay River (SE ¼, NE ¼, sec. 29, T. 1 N., R. 7 W., Green County, Miss.).

Sample	Feet above water level
18	16
19	12
20	6

Locality 4.—Given's Landing on right bank of Chickasawhay river. (NE ¼, NE ¼, sec. 28, T. 1 N., R. 7 W., Green County, Miss.).

	Feet above water level
21	3
22	1

Locality 5.—Bluff on right bank of Chickasawhay river, 100 feet west of mouth of Gatling Creek (SW ¼, NW ¼, sec. 22, T. 1 N., R. 7 W., Green County, Miss.).

Sample	Feet above water level
23	17
24	11
25	3
26	1

Locality 6.—McCray Bluff on right bank of Pascagoula river. (SE cor. sec. 35, T. 2 S., R. 8 W., George County, Miss.).

Sample	Feet above water level
27	4

Locality 7.—Bed of Pierce Creek. (SW cor., SE ¼, sec. 3, T. 1 N., R. 11 W., Perry County, Miss.). Sample 28. One foot below water level.

Locality 8.—Right bank of Leaf River, 1½ mi. northwest of New Augusta, Miss. (SW cor., SE ¼, sec. 13, T. 3 N., R. 11 W. Perry County, Miss.).

Sample	Feet below water level
29	− 7
30	−17
31	−25

TABLE 1.—DISTRIBUTION OF SPECIES IN SAMPLES FROM PASCAGOULA FORMATION[4]

Sample	*Anomocytheridea pascagoulaensis*	*Anomocytheridea ovata*	*Perissocytheridea malsoni*	*Microcythere johnsoni*	*Microcythere moresiana*	*Cytherura johnsoni*	*Cytheromorpha pascagoulaensis*	*Rotalia beccarii*	*Elphidium gunteri*	*Ammodiscus* sp.	*Rangia johnsoni*	*Eponidella cushmani*	*Ostrea vesti*
1	×	×	×	×	×			×	×	×	×		×
2			?					×	×		×		
3	×	×	×			×	×	×	×	×	×	×	
4													
5													
6													
7													
8	×	×	×				×						
9	?												
10													
11													
12								×	×				
13		×	×					×	×				
14											×		
15	?							×	×	×			
16	×	×	×	×	×	×	×	×	×	×	×	×	
17								×		×			
18													
19													
20													
21			×					×					
22													
23								×	×	×			

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird

Genus ANOMOCYTHERIDEA Stephenson, 1938

ANOMOCYTHERIDEA PASCAGOULAENSIS Mincher, n. sp.

Plate 46, figure 1

Carapace slightly tumid in male, quite tumid in female, the male being more elongate. Left valve slightly larger and overlapping the right. Greatest height, one third the length from posterior. Dorsal margin weakly arched, but slightly angular in the right valve of male; ventral margin straight except a shallow convexity in posterior half of the male right valve. Anterior end broadly rounded; posterior end slightly truncated, and having quite a distinct posteroventral angle on the male right valve. The surface is smooth except for closely spaced normal pore canals which are more prominent on the posterior half. A shallow depression is present just anterior to the middle, in which there is a slight sulcus in the dorsal half.

The line of concrescence coincides with the inner margin. Marginal area is considerably wider on the anterior than posterior end. Radial pore canals number 25 to 30 in anterior, and are slightly visible in posterior and ventral areas. The muscle scar pattern is complex (pl. 46, fig. 1a, b). The hinge of the right valve consists of an anterior series of about twelve narrow small teeth, behind which is a short crenulate socket; a low bar extends back to a series of five prominent cusps at the postero-dorsal angle. The hinge of the left valve consists of a well incised crenulate anterior socket; a short crenulate dention; an indistinct groove to the well incised crenulate socket at the posterior-dorsal angle. The anterior socket of the left valve is more prominent than the corresponding dentition of the right, and

[4] Localities 24–31, inclusive, are unfossiliferous.

the posterior dentition of the right is more prominent than the corresponding socket of the left.

Remarks.—This species may be distinguished from *A. locketti* Stephenson of the "*Potamides matsoni* zone" by an absence of the posterior and anterior ventral flange of the male right valve, by having larger and fewer normal pore canals, and by the narrower carapace of the male. The moults of this species are similar to *A. mayi* Stephenson and are indistinguishable from those of *A. ovata*, n. sp. The species is named for the formation in which it occurs and is described from locality no. 2, sample no. 16.

Types and dimensions.—Holotype, H. V. Howe Collection, no. 2071; male right valve, length, 1.00 mm., width, 0.48 mm. Paratype no. 2072; female left valve, length, 0.90 mm., width, 0.50 mm. Paratype no. 2073; male left valve, length, 1.00 mm., width, 0.50 mm. Paratype no. 2074; female right valve, length 0.86 mm., width, 0.46 mm.

ANOMOCYTHERIDEA OVATA Mincher, n. sp.
Plate 46, figure 2

Carapace tumid, in side view ovate. Left valve overlaps right and is considerably heavier. Greatest height slightly posterior to middle and greatest width at the middle. Dorsal margin gently arched, having the center of the curve near the posterior end of the anterior member of the hinge; ventral margin slightly convex, with more overlap near the center. Anterior end broadly rounded; posterior, rounded to the postero-ventral angle in left valve, but with a more prominent postero-dorsal angle in the right valve. Surface of carapace nearly smooth, except for numerous quite large normal pore canals which become smaller and less numerous as the margins are approached. A slightly depressed, somewhat oblique vertical sulcus is present on the dorsal half and slightly anterior to the middle of the carapace.

The line of concrescence coincides with the inner margin. Marginal area slightly broader on anterior than posterior. Radial pore canals very closely spaced on anterior and posterior, also present but rather indistinct along ventral margin. Muscle scar pattern complex (pl. 46, fig. 2a, b). The hinge of the right valve consists of an anterior series of raised teeth; the teeth gradually becoming depressed into a short crenulate groove at the center of the dorsal margin; the dentition then becomes raised to form a narrow, closely crenulated bar to the posterodorsal angle where it is terminated by a series of four or five prominent cusps. The hinge of the left valve consists of an anterior, well incised, crenulate socket much wider than the corresponding teeth of the right valve; the socket becomes raised and narrower posteriorly and forms a short crenulate bar; a faint groove extends to the posterior crenulate socket which is hardly seen without slightly tilting the valve.

Remarks.—The left valve of the female is heavier than either of the other three of the species and seems to be more easily preserved. The moults of this species, if present, are similar to *A. mayi* Stephenson and are indistinguishable from those of *A. pascagoulaensis*, n. sp. The species is described from locality no. 2, sample no. 16.

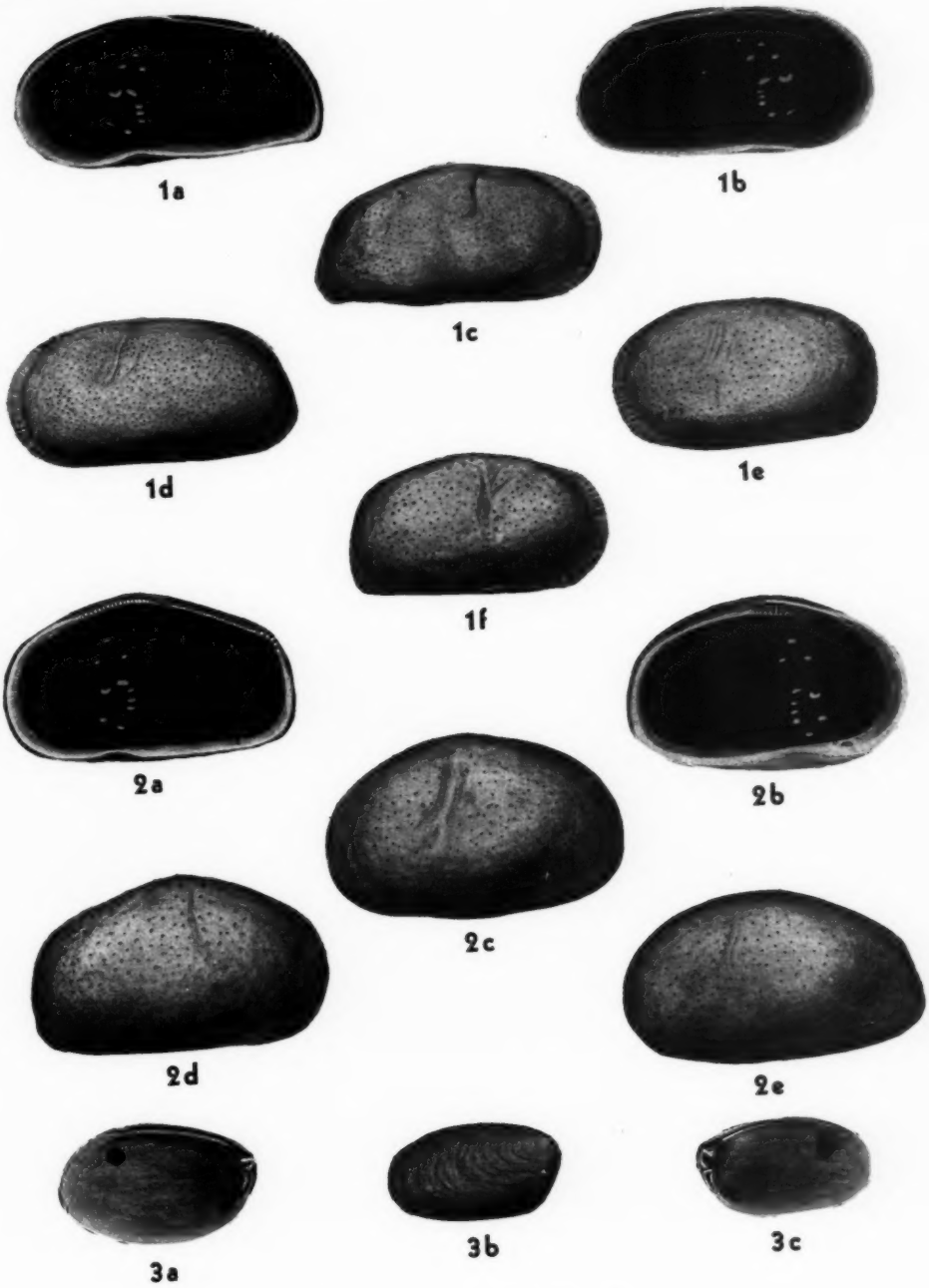
Types and dimensions.—Holotype, H. V. Howe Collection, no. 2075; female left valve, length, 0.98 mm., width, 0.60 mm. Paratype no. 2076; male right valve, length, 0.96 mm., width, 0.53 mm. Paratype no. 2077; male left valve, length, 0.96 mm., width, 0.53 mm. Paratype no. 2078; female right valve, length, 1.00 mm., width, 0.56 mm.

EXPLANATION OF PLATE 46

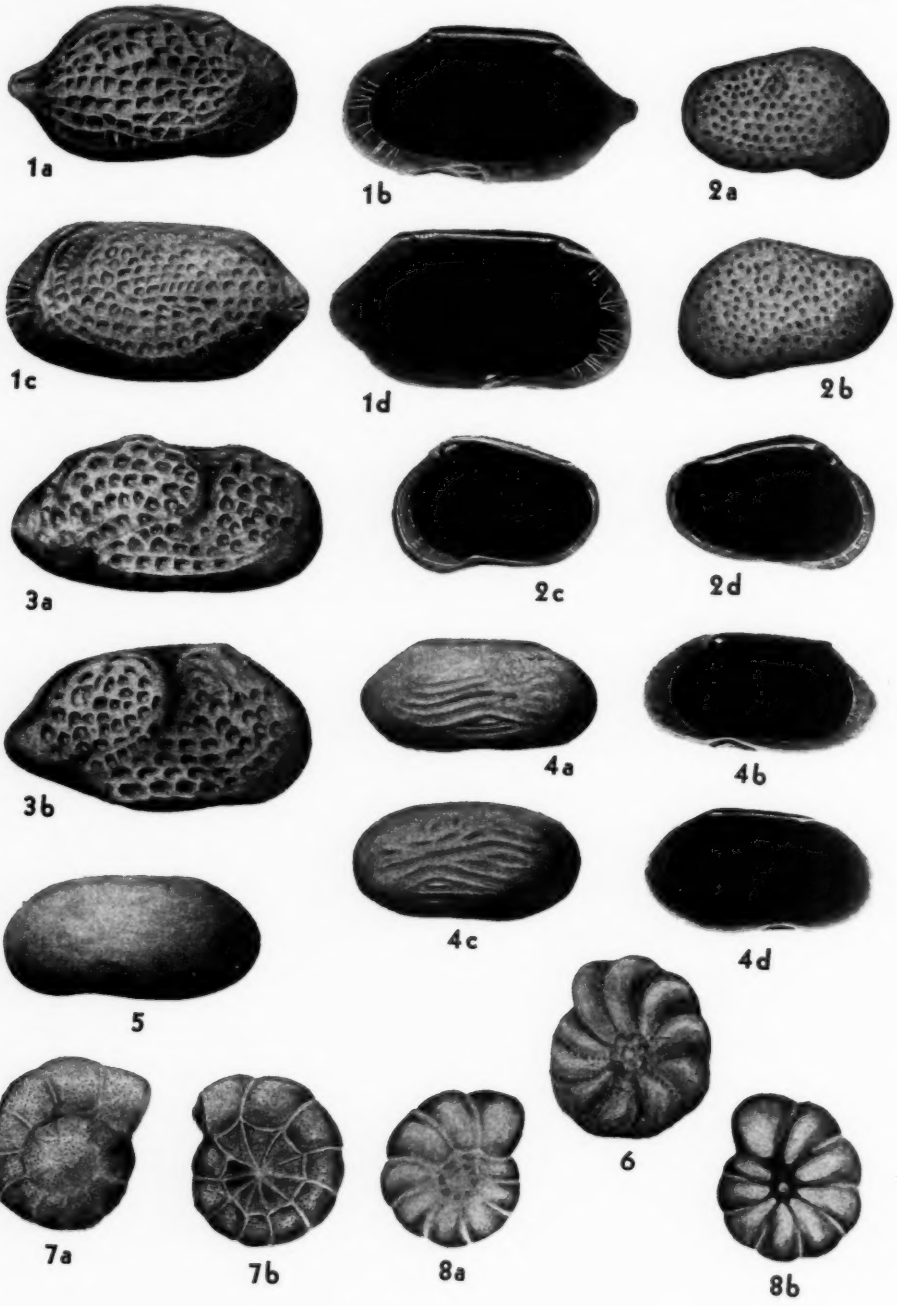
FIGS. *1—Anomocytheridea pascagoulaensis* Mincher, n. sp., ×41. a, Interior view of male right valve; b, Interior view of male left valve; c, Exterior view of male right valve; d, Exterior view of male left valve; e, Exterior view of female left valve; f, Exterior view of female right valve. (p. 341)

2—Anomocytheridea ovata Mincher, n. sp., ×41. a, Interior view of female right valve; b, Interior view of female left valve; c, Exterior view of female left valve; d, Exterior view of female right valve; e, Exterior view of male left valve. (p. 342)

3—Rangia johnsoni Dall a, Interior view of left valve, ×5.4; b, Exterior view of right valve, ×3.8; c, Interior view of right valve, ×3.8. (p. 347)



Mincher, Tertiary Fossils



Mincher, Tertiary Fossils

Genus PERISSOCYTHERIDEA Stephenson, 1938

PERISSOCYTHERIDEA MATSONI Stephenson
Plate 47, figure 3

Cytheridea? matsoni STEPHENSON, *1935*, Louisiana Dept. Cons. Geol. Bull. 6, pp. 192, 193, pl. 5, figs. 1, 2, 7, 8.
Perissocytheridea matsoni STEPHENSON *1938*, Jour. Paleontology, vol. 12, no. 2, pp. 145, 146, pl. 23, fig. 10; pl. 24, fig. 3, 4; text figs. f, 7, 11.

Types and dimensions.—Homeotype, H. V. Howe Collection, no. 2079; female right valve, length, 0.66 mm., width, 0.33 mm. Homeotype no. 2080; male right valve, length, 0.65 mm., width, 0.35 mm.

Locality.—Locality no. 2, sample no. 16.

Genus CYTHERURA Sars, 1865

CYTHERURA JOHNSONI Mincher, n. sp.
Plate 47, figure 1

Carapace small. Dorsal and ventral margins sub-parallel, converging anteriorly. Prominent eyespot may or may not be present. Carapace somewhat tumid in posterior. The anterior end is obliquely rounded and the posterior end is extended into a caudal process, that of the left valve being wider than the right. Surface ornamentation consists of a well defined reticulate pattern of sharp ridges that completely covers the carapace. The pits are arranged in nearly straight rows on the ventral portion. The left valve overlaps the right except on the dorsal margin.

Muscle scar pattern indistinct. Marginal area quite broad on anterior and posterior. Line of concrescence coincides with inner margin except for an indentation toward the caudal process. Radial pore canals number about 10 on anterior with none visible on posterior. The hinge of the right valve consists of an anterior tooth, behind which is a socket; the dorsal margin forms a projecting ridge which is terminated posteriorly beside a socket, near which is a tooth at the inward curving end of the posterior margin. The hinge of the left valve consists of two slight anterior cusps, between which is a depression to receive the tooth of the right valve; posteriorly is one tooth followed by a slight depression.

Remarks.—This species is named in honor of L. C. Johnson, who named the Pascagoula formation, and it is described from locality no. 2, sample no. 16.

Types and dimensions.—Holotype, H. V. Howe Collection, no. 2081; left valve, length, 0.80 mm., width, 0.46 mm. Paratype no. 2082; right valve, length, 0.76 mm., width, 0.46 mm.

Genus MICROCYTHERE Muller, 1894

MICROCYTHERE MORESIANA (Stephenson)
Plate 47, figure 5

Microcythere? moresiana STEPHENSON, *1935*, Louisiana Dept. Cons. Geol., Bull. 6, pp. 191, 192, pl. 5, figs. 3–6, 9.

Remarks.—In describing the hinge structure of this species, the author did not have the specimens correctly oriented. Therefore, in the description, the anterior becomes posterior and the right valve becomes the left, and conversely. The hinge is essentially the same as that of *M. johnsoni*, n. sp. Locality no. 2, sample no. 16.

Type and dimension.—Homeotype, H. V. Howe Collection, no. 2083; left valve, length, 0.58 mm., width, 0.30 mm.

EXPLANATION OF PLATE 47

FIGS. *1*—*Cytherura johnsoni* Mincher, n. sp., ×51. a, Exterior view of right valve; b, Interior view of right valve; c, Exterior view of left valve; d, Interior view of left valve. (p. 343)
2—*Cytheromorpha pascagoulaensis* Mincher, n. sp., ×63. a, Exterior view of right valve. b, Exterior view of left valve. c, Interior view of right valve. d, Interior view of left valve. (p. 344)
3—*Perissocytheridea matsoni* Stephenson, ×63. a, Exterior view of female right valve; b, Exterior view of male right valve. (p. 343)
4—*Microcythere johnsoni* Mincher, n. sp., ×63. a, Exterior view of right valve; b, Interior view of right valve; c, Exterior view of left valve; d, Interior view of left valve. (p. 344)
5—*Microcythere moresiana* Stephenson, exterior view of left valve, ×63. (p. 343)
6—*Elphidium gunteri* Cole, ×57. (p. 345)
7—*Eponidella cushmani* Stephenson, ×119. a, Dorsal view; b, Ventral view. (p. 345)
8—*Rotalia beccarii* Linneaus, ×108. a, Dorsal view; b, Ventral view. (p. 345)

MICROCYTHERE JOHNSONI Mincher
n. sp.
Plate 47, figure 4

Carapace small. In side view subovate. Highest point one-third the length from posterior. Surface ornamentation consists of numerous curved, subparallel longitudinal ridges, not extending to the anterior or posterior ends but visible almost to the dorsal and ventral margins. The ridges become obscure over the muscle scar area. Ventral margin very slightly concave; dorsal margin straight in right valve and very slightly convex in the left. Anterior end obliquely rounded toward the ventral; posterior end subangular in right valve and rounded in the left. Normal pore canals are numerous and very small.

Radial pore canals are moderate in number, straight, simple and are present on anterior, ventral and posterior margins, but on some specimens they are indistinct. The inner lamella is moderately broad on the anterior and becomes depressed near the outer lamella on the ventral and posterior. The ventral margin of the left valve is raised, anterior to the center, to interlock a corresponding groove in the right. Muscle scar pattern is indistinct. The valves seem to fit together with no overlap except where the left valve overlaps the right just behind the dorsoposterior angle.

The hinge of the right valve consists of an anterior tooth, separated from the raised outer margin by a groove; the outer margin continues as a bar to the posterior where it becomes slightly elevated beside an elongate socket, the margin continues to be raised and narrow dorsally for a short distance. The hinge of the left valve consists of raised anterior and posterior dental areas connected by a bar. The anterior tooth of the right valve fits against the depressed inner lamella of the left. The anterior tooth of the left valve does not have a corresponding socket in the right valve but fits against and inside the margin of the carapace; the posterior dentition fits into a corresponding socket in the right valve. Following the posterior dentition of the left valve is a diagonal groove across the marginal area.

Remarks.—This species may be distinguished from *M. moresiana* Stephenson by having a surface ornamentation of longitudinal ridges. It is named in honor of L. C. Johnson who discovered the Pascagoula formation, and is described from locality no. 2, sample no. 16.

Types and dimensions.—Holotype, H. V. Howe Collection, no. 2084; right valve, length, 0.53 mm., width, 0.27 mm. Paratype, no. 2085; left valve, length, 0.52 mm., width, 0.27 mm.

Genus CYTHEROMORPHA Hirschmann, 1901

CYTHEROMORPHA PASCAGOULAENSIS
Mincher, n. sp.
Plate 47, figure 2

Carapace small. Greatest height at center, the slope being about equal toward either end. Dorsal margin straight to slightly sigmoid. Ventral margin of the left valve is very slightly concave, that of the right having an acute concavity near its anterior termination which interlocks the left valve. The right valve extends slightly beyond the left around the entire margin except for the above concavity and the dorsoposterior angle. Surface ornamentation consists of a reticulate pattern, forming small, subangular pits. No normal pore canal can be seen.

The muscle scar pattern is indistinguishable. Inner lamella extends beyond the line of concrescence on the anterior, ventral and posterior portions of the carapace. Radial pore canals number about seven on the anterior. The hinge of the right valve consists of an anterior tooth, surrounded by a shallow socket; the dorsal margin of the carapace forms a bar which becomes higher and thicker at the posterior to form a slightly crenulate dentition. The hinge of the left valve consists of two anterior teeth, between which is a socket; the second of these teeth forms the anterior end of a long bar formed by the dorsal margin of the valve; the bar ends posteriorly in a raised portion beyond which is a groove to receive the dentition of the right valve.

Remarks.—This species is described from locality no. 2, sample no. 16 and named for the formation in which it occurs.

Types and dimensions.—Holotype, H. V. Howe Collection no. 2086; right valve, length, 0.47 mm., width, 0.30 mm. Paratype,

no. 2087; left valve, length, 0.47 mm., width, 0.30 mm.

Order FORAMINIFERA d'Orbigny

Family NONIONIDAE Reuss

Genus ELPHIDIUM Montfort, 1808

ELPHIDIUM GUNTERI Cole
Plate 47, figure 6

Elphidium gunteri COLE, *1931*, Florida Geol. Survey Bull. 6, pp. 34, 35, pl. 4, figs. 9, 10.

Types and dimensions.—Hypotype, H. V. Howe Collection no. 2089; longest diameter, 0.45 mm., thickness, 0.23 mm.

Locality.—Locality no. 2, sample no. 16.

Family ROTALIIDAE Reuss

Genus EPONIDELLA Cushman and Hedberg, 1935

EPONIDELLA CUSHMANI Stephenson
Plate 47, figure 7

Eponidella cushmani STEPHENSON, *1935*, Louisiana Geol. Survey Bull. 6, pp. 189, 190, pl. 5, figs. 17–19.

Type and dimensions.—Homeotype, H. V. Howe Collection no. 2088; greatest diameter, 0.21 mm., thickness, 0.10 mm.

Locality.—Locality no. 2, sample no. 16.

Genus ROTALIA Lamarck, 1804

ROTALIA BECCARII (Linnaeus)
Plate 47, figure 8

Nautilus beccarii LINNAEUS, *1767*. Syst. Nat., ed. 12, p. 1162;—*1788*, ed. 13 (Gemlin's) p. 3370.
Rotalia (*Turbinulina*) *beccarii* D'ORBIGNY, *1826*, Annals sci. nat., vol. 7, p. 275, no. 42; Modeles, no. 74.
Rotalia beccarii CUSHMAN, *1930*, U. S. Nat. Mus. Bull. 104, pp. 58–60, pl. 12, figs. 1–7; pl. 13, figs. 1, 2.

Type and dimensions.—Morphotype, H. V. Howe Collection no. 2090; greatest diameter, 0.22 mm., thickness, 0.10 mm.

Locality.—Locality no. 2, sample no. 16.

Family AMMODISCIDAE Rhumbler

Genus AMMODISCUS Reuss, 1861

AMMODISCUS sp.

Specimens of a species of *Ammodiscus* were found in several samples of the Pascagoula. Specimen no. 2091 in the H. V. Howe Collection is from locality 2, sample no. 16; diameter, 0.65 mm., thickness, 0.06 mm.

Class PELECYPODA Goldfuss

Order PRIONODESMACEA Dall

Family OSTREIDAE Lamarck

Genus OSTREA Linnaeus, 1758

OSTREA WESTI Mincher, n. sp.
Text figures 1–4

Shell large, elongate and moderately curved. The left, or attached, valve is quite deep and the right nearly flat. The valves are thick near the dorsal margin and become thin ventrally, being built up by a succession of calcareous and chonchiolinous laminae; the ends of the laminae forming a crudely concentric, unornamented, rough surface. Left valves of four or five individuals may be attached to one another.

The resilium is roughly triangular in shape; about 2¾ inches long, and 1½ to 2 inches wide on the ventral edge; usually produced to a point on the dorsal end; depressed in the left and raised in the right valve along the longitudinal axes; and slightly extended over the body cavity in the left valve.

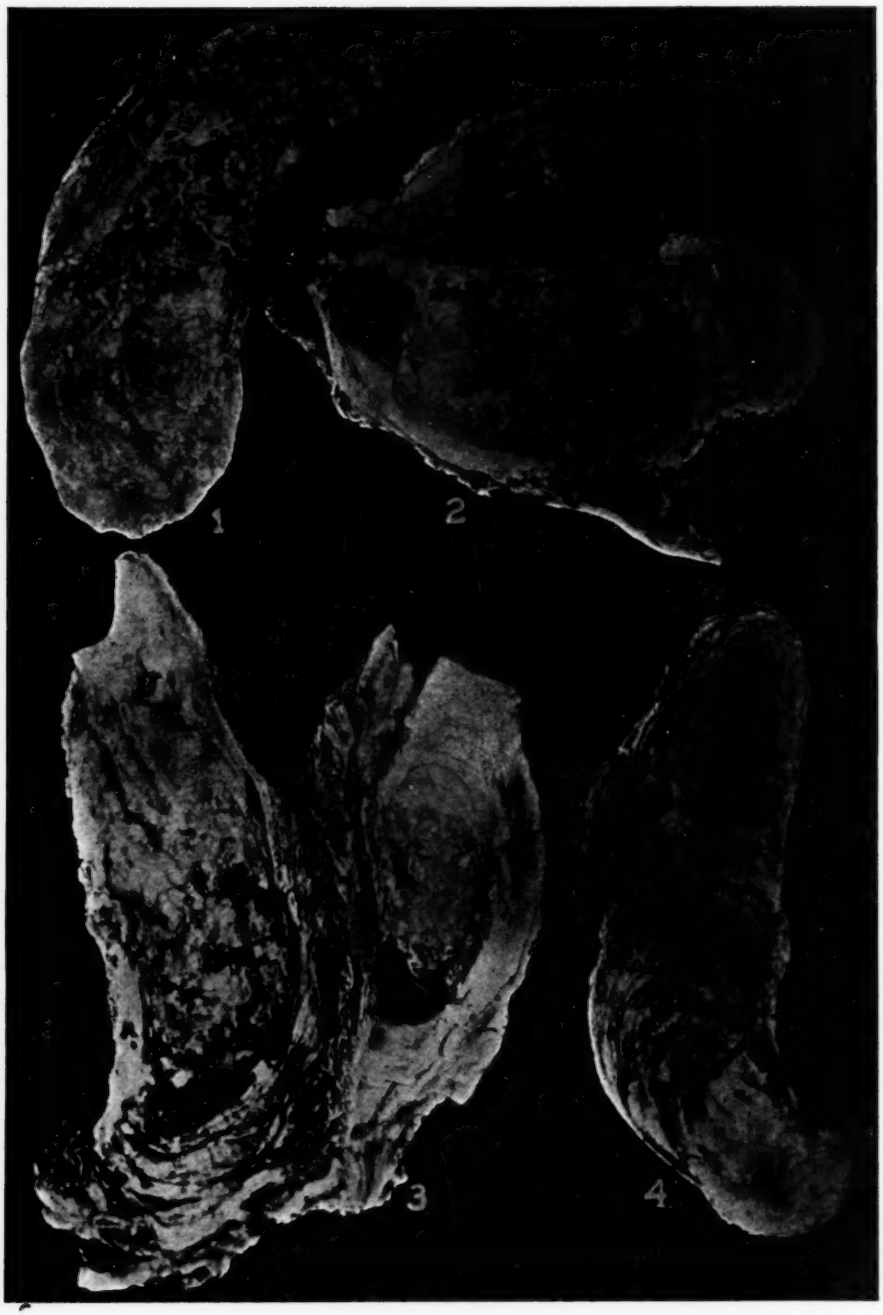
Remarks.—This species is named in honor of J. Frank West, paleontologist, Shell Petroleum Corporation, Houston, Texas, who collected the type specimens. Most specimens when found are badly weathered and too friable to withstand even careful transportation. The species is much less massive than *O. blanpiedi* Howe; less elongate than *O. gigantissima* Finch; retains part of the organic exterior which is rarely extant on the two above species; and is more elongate than *O. titan* Conrad, the large oyster of the California Miocene. This species is described from locality no. 1, the type locality of the Pascagoula formation.

Johnson (1892), in discussing the shells discovered at Shell Bluff stated that the large oyster was the only one that could be determined,—

> But as I remember them, the oyster approached, yet differed from the recent *O. virginiana*, among other particulars, in its greater massiveness.

Howe (1937) gave an interesting discussion of the large oysters of the Gulf Coast Tertiary but no mention was made of this species.

Types and dimensions.—Holotype, Louisiana State University Geological Museum



FIGS. *1–4—Ostrea westi* Mincher, n. sp., ×0.36. *1*, Interior view of right valve; *2–3*, Interior views of left valves; *4*, Exterior view of right valve.

no. 1300 (text fig. 2). Paratypes, nos. 1301–1303 (text figs. 1, 3, 4). Maximum dimensions of type specimens; length, 12 inches; width, 4 inches; depth, 3 inches.

Order TELEODESMACEA Dall

Superfamily MACTRACEA Gray

Family MACTRIDAE Gray

Genus RANGIA Desmoulins, 1832

RANGIA JOHNSONI (Dall)

Plate 46, figure 3

Gnathodon johnsoni DALL, *1892*, Science, vol. 20, no. 502, p. 165, (*nomen nudum*);—, *1892*, Wagner Free Inst. Sci. Bull., vol. 3, pt. 2, p. 337, pl. 22, fig. 18;—, *1894*, U. S. Nat. Mus. Proc., vol. 17, pp. 100, 101, pl. 7, fig. 7.

Venus mobilina JOHNSON, *1892*, Science, vol. 20, no. 501, p. 151 (*nomen nudum*).

Rangia johnsoni DALL, *1898*, Trans. Wagner Free Inst. Sci. Bull., vol. 3, pt. 4, p. 905, pl. 22, fig. 18.

Rangia johnsoni was pictured and described by Dall (1892, pl. 18, and 1894, pp. 100–101) from Shell Bluff on the Chickasawhay river and from artesian wells at Hiloxi, Mississippi and Mobile, Alabama. He considered it to be Miocene. This fossil has been of much importance in subsurface correlation along the Gulf Coast since Jennings, the first oil field in South Louisiana was discovered (Deussen, 1902, pp. 269, 270, and 1910, pp. 55–61).

Types and dimensions.—Topotypes; Louisiana State University Geological Museum no. 1304, left valve, length 6.5 mm., width 3 mm. (pl. 46, fig. 3a); no. 1305, right valve, length 5.0 mm., width 2.6 mm. (pl. 46, figs. 3b, c).

Locality.—Types are from locality no. 1, the type locality of the Pascagoula formation.

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MANUSCRIPT RECEIVED BY THE EDITOR MARCH 17, 1940.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 4, PP. 349–353, PL. 48, 1 TEXT FIG., JULY, 1941

FUSULINIDS FROM THE TYPE SECTION OF THE LOWER PENNSYLVANIAN QUADRANT FORMATION[1]

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ABSTRACT—One species each of the fusulinid genera *Wedekindellina* and *Fusulina* are described and illustrated from the type section of the Quadrant formation at Quadrant Mountain, Wyoming. This is the first time any fossils have been illustrated or described, or even listed by name, from this type section. These fusulinids clearly indicate middle Des Moines age for the upper portion of the Quadrant at its type locality. Also, the Quadrant is redefined so as to include in the formation all beds present at Quadrant Mountain considered Pennsylvanian in age.

THE formation name Quadrant was published by Peale (1893) and applied to approximately 350 feet of strata found in the area northeast of Three Forks, Montana, and considered "Upper Carboniferous" in age. A part of the section at Quadrant Mountain, Wyoming, about 75 miles south by east of the Three Forks area, was described in a very general way by Weed (1896) as "Quadrant quartzite" and was designated as the type locality of the Quadrant. However, a detailed description of this type section at the southeast corner of Quadrant Mountain was published for the first time by Iddings and Weed (1899). Peale (1893, p. 14) clearly states that his nomenclature was adopted for Montana after consultation with Hague's division, of which Weed was a member, and it is obvious that Peale considered the Quadrant of the Three Forks area equivalent in age to at least a part of the section at Quadrant Mountain.

The detailed description of the type section at Quadrant Mountain published by Iddings and Weed (1899) included about 400 feet of beds in the Quadrant formation between the Madison limestone (Mississippian) below and the "Teton formation" (Permian and Triassic) above. Various thicknesses have been given for this type section of the Quadrant as defined by Iddings and Weed. Condit, Finch, and Pardee (1928, p. 188) stated that the section measured by them at the southeast corner of Quadrant Mountain gave a thickness of 460 feet for the Quadrant formation. Scott (1935) has remeasured this section and gives a thickness of 345 feet for all of the beds between the Madison limestone below and the Phosphoria formation above.

Iddings and Weed apparently did not find any fossils in the Quadrant section at Quadrant Mountain because Girty (1899) described the "Devonian and Carboniferous fossils" collected by Iddings and Weed and others from the Yellowstone Park area and mentions the "unfossiliferous Quadrant quartzite". Condit (1919) and Scott (1935) recognized that the lower portion of the Quadrant formation at Quadrant Mountain is Mississippian in age and that the upper portion is referable to the Pennsylvanian. Condit states "field work in 1916 showed that the typical Quadrant in the Yellowstone Park, as described by Iddings and Weed in Monograph 32, included representatives of both upper Mississippian and the Pennsylvanian", but Condit did not attempt to restrict the formation to strata of either system nor did he mention any part of the fauna found at Quadrant Mountain. Scott considered the lower portion of the original Quadrant Mississippian in age and referred it to the Amsden formation. He restricted the Quadrant to the upper or Pennsylvanian portion of Iddings and Weed's original section. However, the exact position of the break between Mississippian and Pennsylvanian at Quadrant Mountain

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has not been definitely defined. Paleontological studies of the megafauna by the associate author of this report indicate that beds one and two of Scott's section measured in 1934, and reproduced below, are Mississippian in age and beds three to 21 are Pennsylvanian in age. We are, therefore, including beds three to 21 in the Quadrant formation and deleting the name Amsden from the section.

The following is a revision of the section measured by Scott (1935, p. 1017) on the southeast corner of Quadrant Mountain.

Quadrant Mountain Section

Phosphoria formation (Permian)
Quadrant formation (Pennsylvanian)

Bed	*Thickness* Feet
21. Gray brecciated limestone	7
20. Quartzitic sandstone	2
19. Light gray, cherty, siliceous limestone with sandstone lenses; brachiopod fragments, *Wedekindellina* cf. *W. excentrica* (Roth and Skinner) and *Fusulina* sp.	14
18. Massive, saccharoidal, tan-colored sandstone	15
17. Brown to white quartzite	2
16. Cherty, compact limestone	6
15. Cross-bedded, ripple-marked quartzite, black on surface	11
14. Calcareous quartzite	8
13. Cross-bedded, coarse grained, tan-colored sandstone; erosional surface at base	6
12. Light gray, cherty, and fossiliferous limestone	8
11. Hard sandstone, like quartzite	29
10. White to brown quartzite	10
9. Gray limestone	2
8. Cross-bedded gray quartzite, sandy at base, calcareous at top	116
7. Dolomitic limestone	10
6. Hard sandstone	3
5. Gray limestone	5
4. Calcareous sandstone	4
3. Light gray limestone with a two-inch shale parting near base	21

Sacajawea? formation (Mississippian)

2. Yellow to brown shale	5
1. Red to purple sandy shale, tends to be covered but well exposed on south side of mountain	61

Madison limestone (Mississippian)

The portion of the Pennsylvanian to which the type section of the Quadrant is referable has not been previously established. Scott discovered Foraminifera in a calcareous sandstone 10 to 15 feet below the top of the formation on the southeast corner of Quadrant Mountain (bed 19 of accompanying section). We have made numerous sections of this material and have obtained representatives of the fusulinid genera *Wedekindellina* and *Fusulina*. Although this material is rather poorly preserved, we feel that it should be illustrated and described in detail since no other fossils have been illustrated or described, or even listed by name, from the type section of the Quadrant formation in its broad sense or in the restricted sense as we are using the name in this report.

Condit, Finch, and Pardee (1928, p. 192) reported the occurrence of "*Fusulina*," about 20 miles west of Quadrant Mountain in strata approximately 50 feet below the top of what they considered the Quadrant formation. Love (1939) has restudied Condit, Finch, and Pardee's material and reports it as representing the genus *Wedekindellina* and that it is considered by Dunbar to be Cherokee in age. Until 1937 the genus *Wedekindellina* was generally believed restricted in America to the mid-portion of the Des Moines series. However, Newell

EXPLANATION OF PLATE 48

All illustrations on this plate are unretouched photographs and all are magnified ×20.

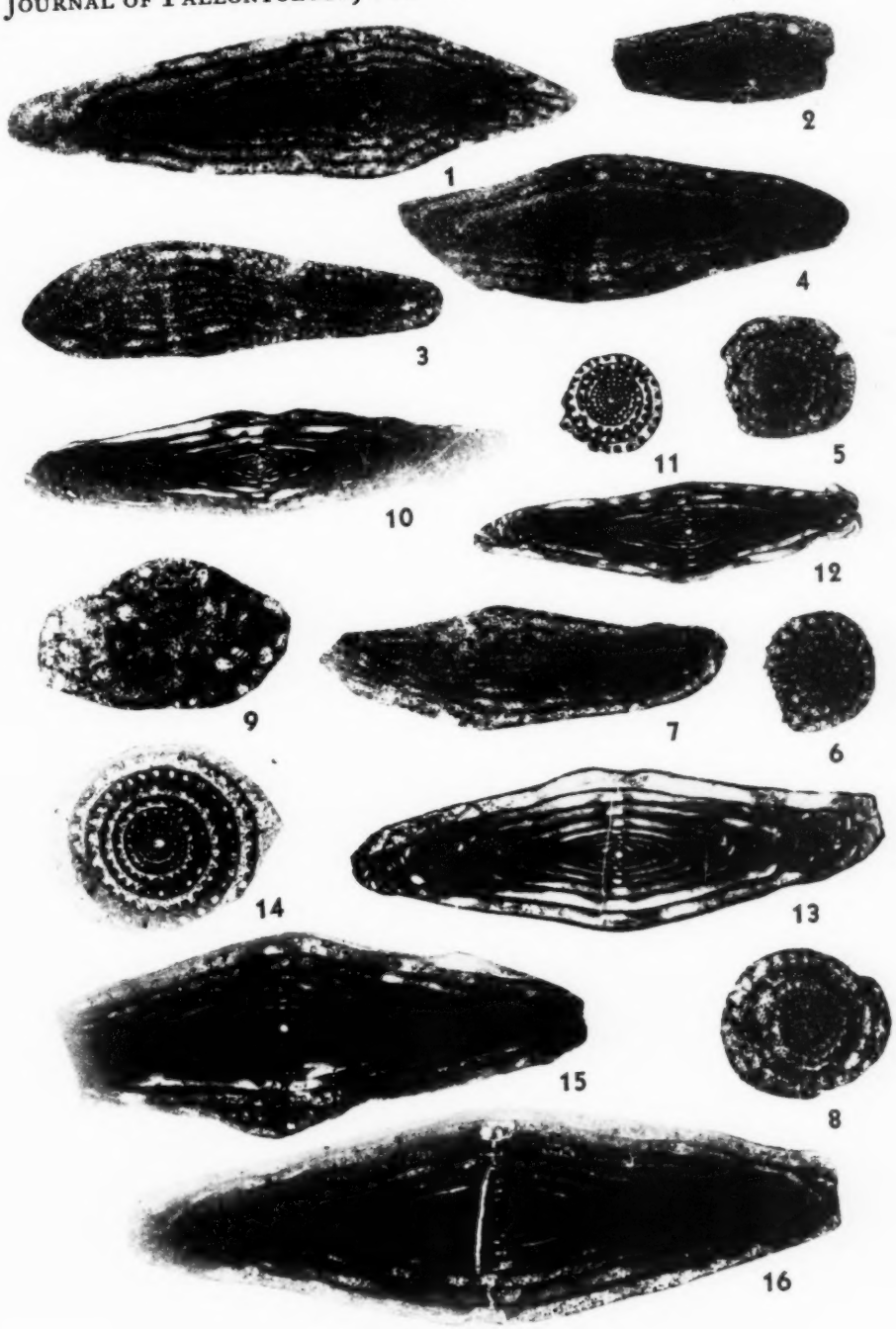
FIGS. *1–8*—*Wedekindellina* cf. *W. excentrica* (Roth and Skinner). *1, 2, 4*, Axial sections; *3, 7*, tangential sections; *5, 6, 8*, sagittal sections. From the upper portion of the type section of the Quadrant formation. (p. 352)

9—*Fusulina* sp. Oblique section of a specimen partially filled with limonite. From the upper portion of the type section of the Quadrant formation. (p. 353)

10–12—*Wedekindellina euthysepta?* (Henbest). *10, 12*, Axial sections; *11*, sagittal section. From the upper portion of the Cherokee formation of Lucas County, Iowa. Same specimens illustrated by Thompson in 1934. (p. 352)

13—*Wedekindellina euthysepta?* (Henbest). Axial section of a specimen which was illustrated by Needham in 1937 as a polished section. From the Magdalena formation in Tijeras Canyon, New Mexico. (p. 353)

14–16—*Wedekindellina excentrica* (Roth and Skinner). *14*, Sagittal section; *15, 16*, axial sections. From the Hartville formation near Guernsey, Wyoming. Same specimens illustrated by Thompson in 1936. (p. 352)



Thompson and Scott, Pennsylvanian Fusulinids

UNIV. OF MICH.

and Keroher (1937) reported *Wedekindellina* from the lower portion of the Missouri series of Kansas and Missouri associated with primitive *Tricticites*, and hence *Wedekindellina*, as the genus is now defined, is not strictly indicative of Des Moines age. With the exception of the report by Newell and Keroher and Love's report of *Wedekindellina* from what is considered Quadrant in Montana, all reports concerning the occurrence of *Wedekindellina* in America (fig. 1) show its association with, or occurrence stratigraphically below, representatives of the genus *Fusulina* of the type restricted to the mid-portion of the Des Moines series.[2] So far as known, the genus *Fusulina* is restricted in America to strata of upper Cherokee and Marmaton ages (Des Moines series). It therefore seems to us that the occurrence of *Wedekindellina* and a primitive species of *Fusulina* associated in the upper portion of the Quadrant formation at its type locality establishes beyond reasonable doubt the age of that portion of the Quadrant as middle Des Moines, and supports the conclusion by Dunbar that the form found about 20 miles west of Quadrant Mountain is also Des Moines in age.

Branson (1939) has redefined the Tensleep formation at its type locality along Tensleep creek on the west side of the Bighorn Mountains so as to include in the Tensleep all Pennsylvanian strata between the Chugwater formation (Triassic and Permian) above and "beds of Chester? age" (Mississippian) below. In other words, Branson proposed to include in the Tensleep formation all of the Pennsylvanian strata found at the type locality of the formation. The only fusulinids which Branson reports from any portion of the Tensleep in central Wyoming are "*Fusulina* n. sp. and *Staffella* sp." from about 175 feet below the Phosphoria on the walls of Bighorn River, 7 miles south of Thermopolis. Branson states (p. 1219) that the species of *Fusulina* found near Thermopolis is identical with a new species of *Fusulina* found at the top of Division IV of the Hartville formation near Guernsey, Wyoming, as that formation is

FIG. *1*. Map of a portion of United States showing the geographic distribution of species of *Wedekindellina*. *1*, *W. euthysepta* (Lower Magdalena formation), 10 miles northwest of Socorro and near Kelly, New Mexico; *1a*, *W. euthysepta* and *W. excentrica* (Lower Magdalena formation), Tijeras Canyon, New Mexico; *2*, *W. euthysepta* (Lower Magdalena formation), Montezuma Hot Springs, New Mexico; *3*, *W. coloradoensis* and *W. excentrica* (Hermosa formation), near Durango, Colorado; *4*, *W. coloradoensis*, *W. coloradoensis perforata*, *W. excentrica*, *W. excentrica magna* (McCoy formation), near McCoy, Colorado; *5*, *W.* cf. *W. excentrica* and *W.* sp. (Quadrant formation), Yellowstone National Park, Wyoming, and southwestern Montana, respectively; *6*, *W. excentrica* (Hartville formation), near Guernsey, Wyoming; *7*, *W. euthysepta* (Dennison limestone), near Dennis, Texas; *8*, *W. euthysepta?* (Atoka formation), Pontotoc County, Oklahoma; *9*, *W. euthysepta* (Atoka formation), Latimer County, Oklahoma; *10*, *W. henbesti* (Cherokee formation), northeastern Oklahoma; *11*, *W. ultimata* (Bethany Falls limestone), eastern Kansas; *12*, *W. ultimata* (Bethany Falls limestone), Jackson County, Missouri; *13*, *W. euthysepta?*, *W. uniformis*, *W. elfina*, and *W. dunbari* (Cherokee formation), Lucas and Monroe counties, Iowa; *14*, *W. euthysepta?* (Cherokee formation), Van Buren County, Iowa; *15*, *W. euthysepta* and *W. minuta* (Stonefort limestone), Saline and Williamson counties, Illinois.

[2] *Wedekindellina euthysepta* was reported by Needham (1937) from the Magdalena formation near Montezuma Hot Springs, New Mexico (see fig. 1), and no mention was made of associated representatives of *Fusulina*. However, the senior author of the present report is making a detailed study of the Pennsylvanian stratigraphy of New Mexico and Needham kindly has made his original collections available. Additional sections from the Montezuma Hot Springs locality have yielded a primitive species of *Fusulina*.

divided by Condra and Reed (1935). This would indicate that the middle portion of the Tensleep near Thermopolis is equivalent in age to the mid-portion of the Des Moines series of the Mid-Continent area and also equivalent in age to the upper portion of the Quadrant formation at Quadrant Mountain.

Love (1939) reports the occurrence of the genus *Fusulinella* 9 feet below the top of the section which he considers Amsden on the east wall of Wiggins Fork Canyon in the southern portion of the Absaroka Range. If Branson's definition of the Tensleep is to be followed, the portion of the "Amsden" in the Absaroka Range which contains *Fusulinella* should apparently be classified as Tensleep. Further study may yield representatives of the genus *Fusulinella* in the type section of the Quadrant, but at the present time we have no basis for correlating these *Fusulinella*-bearing beds discovered by Love with any portion of the section at Quadrant Mountain. However, the beds which contain *Fusulinella* in the Absaroka Range may be equivalent in age to the lower portion of the typical Quadrant as the formation is defined in this report.

SYSTEMATIC DESCRIPTIONS

Genus WEDEKINDELLINA Dunbar and Henbest, 1933

WEDEKINDELLINA cf. W. EXCENTRICA (Roth and Skinner)

Plate 48, figures 1–8

Wedekindella excentrica ROTH and SKINNER, *1930*, Jour. Paleontology, vol. 4, pp. 340–341, pl. 30, figs. 1–3; THOMPSON, *1936*, idem, vol. 10, pp. 105–106, pl. 15, figs. 6, 9 (not figs. 10, 11), pl. 16, fig. 12.

(?) *Wedekindellina excentrica* NEEDHAM, *1937*, New Mexico School of Mines, Bull. no. 14, pp. 29–30, pl. 3, figs. 9–11, pl. 4, fig. 1.

Shell small, elongate fusiform, poles pointed to narrowly rounded; largest specimens contain seven to nine volutions and measure 3.7 to 4.5 mm. in length and 1.1 to 1.3 mm. in width. The form ratio of the largest specimens is 1:3.2 to 1:4.0. Axis of coiling straight to slightly irregular.

The exact structure of the septa and the spirotheca cannot be determined from our specimens. However, the septa and spirotheca are thin and conform very closely in thickness to that of other described representatives of this genus from the Des Moines series.

There are 25 septa in the seventh volution and 29 in the eighth volution in one of our best preserved sagittal sections. The septa are unfluted throughout the length of the shell. The tunnel is narrow and its intersection with axial sections is only slightly irregular. The tunnel angle of the eighth volution of two specimens measure 20° and that of the ninth volution of one specimen measures 25°. The chomata are well developed and are about two-thirds as high as the chambers in the seventh and eighth volutions. The axial fillings are very heavy and completely fill the chambers in all volutions except those in the outermost volution.

The rate of expansion of the shell is uniform and the heights of the chambers measured in microns are 48 for the fifth volution, 65 to 73 for the sixth volution, 80 for the seventh volution, 82 to 90 for the eighth volution, and 110 for the ninth volution.

The rather poor state of preservation of our material does not permit very close comparisons with previously described and illustrated representatives of this genus. However, it is obvious from the accompanying illustrations and the above description that our specimens are referable to the genus *Wedekindellina* and they all seem to represent the same species. Our specimens are similar in many respects to the original type specimens of *W. excentrica* from the McCoy formation of Colorado. However, the Quadrant specimens seem to be smaller at maturity and have a smaller form ratio than the Colorado specimens. The form illustrated by Thompson as *W. excentrica* from the Hartville formation of eastern Wyoming (see pl. 48, figs. 14–16) also has a larger form ratio and is larger at maturity than the Quadrant specimens. The Quadrant form resembles in a general way *W. henbesti* (Skinner) from the Cherokee shale of Oklahoma. The form described as *W. euthysepta?* by Thompson from the Cherokee shale of Iowa (see pl. 48, figs. 10–12) is much smaller than the Quadrant form. In general shape and size, the form we have from the Quadrant resembles very closely the specimens described by Needham as *W. euthysepta* from the lower part of the Magdalena

formation of New Mexico (see pl. 48, fig. 13). However, the New Mexico specimens seem to have less well developed axial fillings.

Occurrence.—*Wedekindellina excentrica* was originally described and illustrated from the McCoy formation of Colorado. This species has also been described and illustrated from the Hartville formation of eastern Wyoming and specimens have been referred to this species from the Magdalena formation of New Mexico. Roth (1934) has reported *W. excentrica* from the type locality of the Hermosa formation in southwestern Colorado. The specimens described above came from the upper part of the Quadrant formation (bed 19 of accompanying section) on the southeast corner of Quadrant Mountain, Yellowstone National Park, Wyoming, where it is associated with *Fusulina* sp., described below.

Genus FUSULINA Fischer-de-Waldheim, 1829

FUSULINA sp.
Plate 48, figure 9

The material on which the following description is based seems to be composed of immature specimens. We have not obtained any sections that are well oriented or centered. However, the septal fluting is clearly shown and the spirothecal structure, although not well preserved, seems to conform to that of other representatives of this genus.

Shell small, fusiform; poles blunt to pointed; central portion of the shell inflated. The rate of expansion of the shell is rapid and the height of the chambers in the last volution of our largest specimen, apparently of five volutions, measures 226 microns and that of the chambers in the next to last volution of the same specimen measures 178 microns. The thickness of the largest specimen measures 1.4 mm. There are 24 septa in the last volution of this same specimen. The septa are fluted throughout the length of the shell as well as we can determine but the fluting becomes narrow only in the polar regions. The spirotheca is rather thin and measures 28 to 45 microns in the outer two volutions.

There is no filling in the axial regions.

The characters which are observable in our specimens from the Quadrant formation conform somewhat closely with those of *Fusulina kayi* Thompson of the upper Cherokee shale of Iowa.

Occurrence.—The material on which the brief description given above is based came from the southeast corner of Quadrant Mountain and was collected from bed 19 of the accompanying section, where it is associated with *Wedekindellina* cf. *W. excentrica*, described above.

MANUSCRIPT RECEIVED BY THE EDITOR MAY 14, 1940.

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PENNSYLVANIAN OSTRACODES FROM LAWRENCE COUNTY, ILLINOIS

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ABSTRACT—An ostracode fauna from the Macoupin cyclothem, McLeansboro group, is described. The fauna consists of 13 previously described species and 13 new species. The following genera are represented: *Beyrichiana, Kirkbya, Amphissites, Discoidella, Monoceratina, Bairdia, Macrocypris, Bairdianella, Cytherella, Bythocypris, Cavellina, Basslerella,* and *Cypridellina.*

THE Pennsylvanian sediments exposed along Embarrass River, one mile east of Lawrenceville, Illinois, belong to the Macoupin (Newton and Weller, 1937, p. 12) cyclothem of the McLeansboro group. The ostracodes described in this paper were obtained from the marine limestone member of this cyclothem at this locality.

The Macoupin cyclothem (Wanless, 1931, p. 811) was named from exposures along Macoupin Creek, southeast of Carlinville, Macoupin County, Illinois. Wanless[1] believes that the Macoupin is probably to be correlated with the Bethany Falls formation of the Mid-Continent area. Lithologically, the Macoupin is more or less typical of an Illinois Pennsylvanian cyclothem. It consists, in ascending order, of sandstone, shale, underclay, and coal in the non-marine phase, and thinly laminated black shale, impure limestone, and brownish-gray shale in the marine portion. The thickness of the cyclothem varies considerably, averaging about 40 feet.

The thin, impure, marine limestone is very fossiliferous. Most of the fossils are pyritized or marcasitized and can be removed from the limestone by using very dilute solutions of hydrochloric acid. *Hyperammina, Ammovertella?, Glyphostomella, Tetrataxis, Textularia, Ambocoelia, Dictyoclostus, Linoproductus,* and *Lophophyllum* are common.

The following species of ostracodes have been identified:

[1] Personal communication

Kirkbya canyonensis Harlton, 1929.
Kirkbya punctata Kellett, 1933.
Amphissites centronotus (Ulrich and Bassler), 1906
Bairdia bicornis? Bradfield, 1935
Bairdia garrisonensis Upson, 1933
Bairdia hoxbarensis Harlton, 1921
Bairdia pompilioidea Harlton, 1928
Bairdianella elegans Harlton, 1929
Bythocypris texensis Coryell and Sample, 1932
Bythocypris parallela Knight, 1928
Cytherella tongia? Coryell and Sample, 1932
Cytherella gloria Coryell and Sample, 1932
Cavellina nebrascensis (Geinitz), 1868

In addition to these forms, 13 new species were found. The ostracode fauna cannot be correlated with any other known zone, but is most similar to the Hoxbar fauna of Oklahoma.

There are two unusual features of the Macoupin fauna, the occurrence of *Discoidella*, hitherto unknown above the Mississippian, in Pennsylvanian rocks, and the presence of spines on some species of *Bairdia* and *Basslerella*. *Discoidella* is one of the most common and diagnostic of the ostracodes of the Macoupin limestone. This is the only known record of the genus in the Pennsylvanian; other occurrences are confined to the Chester. The spines on the extremities of some species of *Bairdia* and *Basslerella* appear to be solid. It is most difficult to determine whether a spine was once present on some specimens or if it was broken off close to the carapace.

The illustrations were made by Mr. Maxim M. Elias, of the Iowa Geological Survey.

SYSTEMATIC DESCRIPTIONS

Family ACRONOTELLIDAE Swartz

Genus MONOCERATINA Roth, 1928

MONOCERATINA? NODOSA Scott and Borger, n. sp.
Plate 49, figures 4, 5

Carapace small, sub-oblong in lateral view; dorsum straight in anterior half, convex in posterior half, venter broadly convex. Anterior end broadly convex; posterior end trucate ventrally; cardinal angles obtuse; maximum thickness in posterior half; tumid and irregular in dorsal view. Pronounced sulcus separates anterior node from postrior nodes; shallow sulcus separates ventral and dorsal posterior nodes; spine on posterior ventral node points slightly away from carapace and toward posterior margin. Overlap indistinct; hinge line straight in dorsal view. Length, 0.53 mm.; height, 0.24 mm.

Holotype.—University, of Illinois, Paleontology collection, no. X-1267.

MONOCERATINA LAWRENCEVILLENSIS Scott and Borger, n. sp.
Plate 49, figures 8, 9

Carapace sub-oblong in lateral view; dorsum straight; venter broadly convex; cardinal angles moderately sharp; posterior extremity angular, posterior dorsal slope and posterior ventral slope form an angle of about 60°; anterior broadly rounded. Dorsal view elongate-rhombic; conspicuous spine protrudes from postero-ventral quarter; inconspicuous node near hinge line in anterior third; surface minutely pitted; overlap indistinct; hinge line straight. Length, 0.53 mm.; height, 0.25 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1270.

MONOCERATINA MACOUPENI Scott and Borger, n. sp.
Plate 49, figures 2, 3

Carapace small, sub-oblong in lateral view; dorsum straight; venter broadly convex. Cardinal angles obtuse, anterior cardinal angle smoothly rounded and of lesser degree than posterior cardinal angle; maximum thickness slightly posterior to center of carapace; posterior dorsal slope and posterior ventral slope form an angle slightly less than a right angle; greatest extension of posterior end above median line; surface pitted, pits gradually die out on posterior and anterior extremities; node located along dorsal margin in anterior fourth, merges into carapace ventrally, flanked anteriorly and posteriorly by shallow sinus. Prominent spine developed in postero-ventral half; spine long, gently curved posteriorly, emerges from carapace at point where the posterior ventral straight slope meets broad curvature of venter. Six to eight small teeth protrude anteriorly along anterior margin; right valve grooved on dorsal and ventral margins to receive the large left valve; hinge line straight. Length, 0.56 mm.; height, 0.24 mm.

Holotype.—University of Illinois Paleontology collection no. X-1266.

Family BEYRICHIIDAE Jones, emend. Ulrich and Bassler, 1908

Genus BEYRICHIANA Kellett, 1933

BEYRICHIANA TUMIDA Scott and Borger, n. sp.
Plate 49, figure 1

Carapace sub-ovate in lateral view; cardinal angles a little greater than 90°; dorsum straight; venter convex with moderate backward swing; ends regularly convex; elongate-ovate in dorsal view. Carapace inflated, broken up into three distinct lobate areas by a Y-shaped system of sulci; small triangular radial lobe situated a little in front of center near dorsal margin, sulci posterior and anterior to central triangular node converge beneath it and continue obliquely as one sulcus almost to postero-ventral margin; posterior lobe roughly triangular; small rounded antero-dorsal node and lower elongate node separated by short sulcus; overlap indistinct, hinge line straight and less than the greatest length; surface granular. Length 1.00 mm.; height, 0.70 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1268.

Family KIRKBYIDAE Ulrich and Bassler

Genus AMPHISSITES Girty, 1910 emend Knight, 1928

AMPHISSITES NODOSUS Scott and Borger, n. sp.
Plate 49, figure 12

Carapace sub-oblong in lateral view; cardinal angles a little greater than 90°, usually subequal; dorsum straight to slightly concave, venter broadly convex; ends broadly convex; elongate-ovate in dorsal view. Carapace reticulate, one prominent concentric band of parallel rectilinear reticulations parallel ventral margin. Prominent, rounded, symmetrical, finely reticulate node subcentrally situated. Kirkbyian pit small, subelliptical in shape, two reticulae long, deeply impressed, situated directly below central node; dorsum narrow, elongate-ovate in dorsal view; overlap indistinct. Hinge line straight, a little less than greatest length, slightly depressed. Length, 0.80 mm.; width, 0.46 mm.

Holotype.—University of Illinois Paleontology colection, no. X-1269.

Genus DISCOIDELLA Croneis and Gale, 1938

This genus was established on the basis of specimens obtained from the Golconda by Croneis and Gale. Later, Croneis and Gutke suggested that specimens referred to the genus may not belong to the Ostracoda. The specimens from the Macoupin are strongly convex, subcircular, and reticulated. All the specimens consist of single valves and, in no instance, can a hinge line be recognized.

DISCOIDELLA CONVEXA Scott and Borger, n. sp.
Plate 49, figures 15, 16

Carapace small, subcircular, highly convex; dorsum convex; venter convex; anterior and posterior ends rounding from cardinal angles into venter with a broad and subuniform curvature. No distinguishable lobes or nodes present; area of greatest thickness median; surface of carapace coarsely and neatly reticulated in sub-uniform concentric bands, reticulae become smaller and less distinctly banded near center of valve; a small pit may be present near the center. Length, 0.45 mm.; height, 0.45 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1271.

Remarks.—The dorsal margin is considered to be along the straightest edge. It has proven impossible to determine anterior and posterior ends. Specimens are fairly abunant in the Macoupin.

Family BAIRDIIDAE Lienenklaus

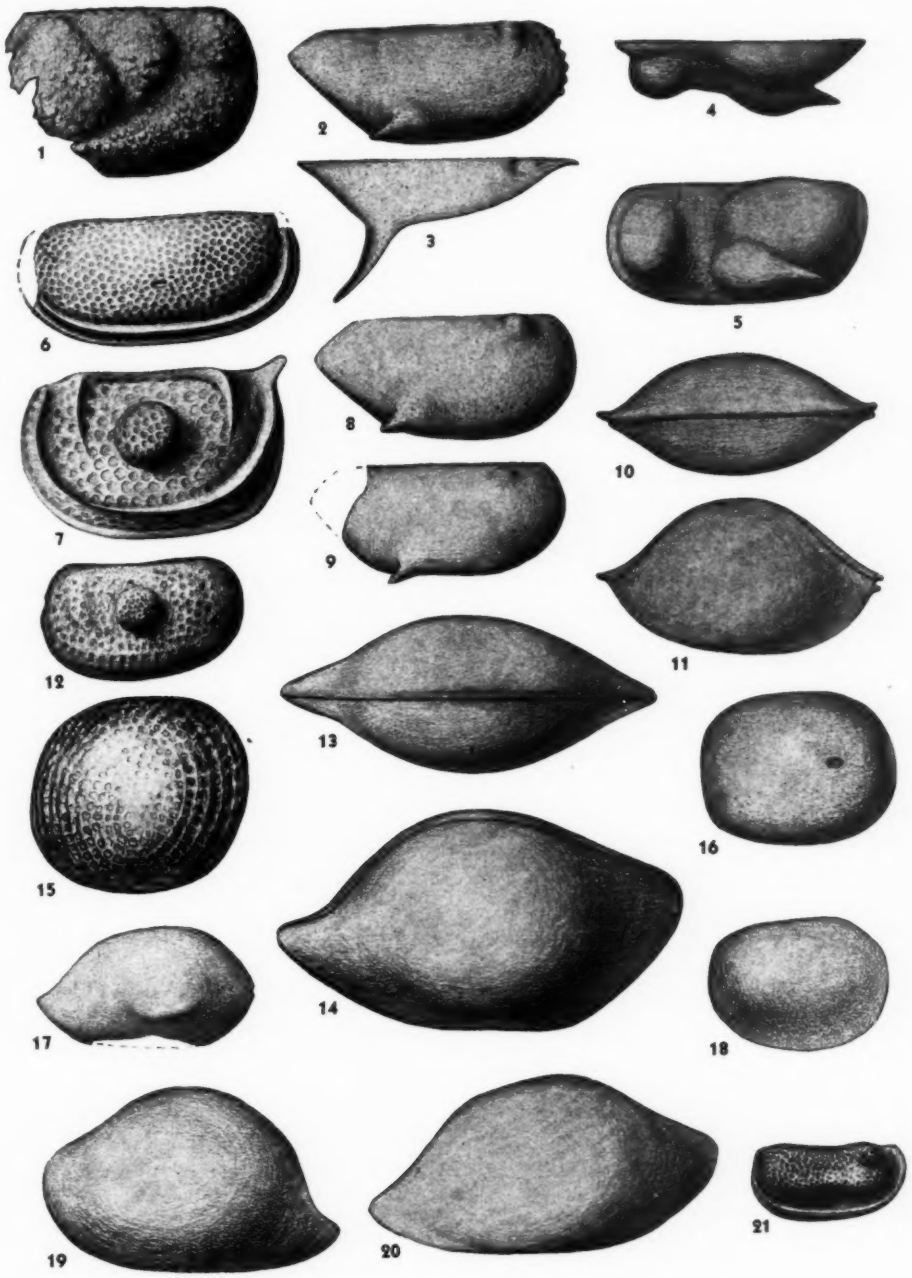
Genus BAIRDIA McCoy, 1844

BAIRDIA WABASHENSIS Scott and Borger, n. sp.
Plate 50, figures 18, 19

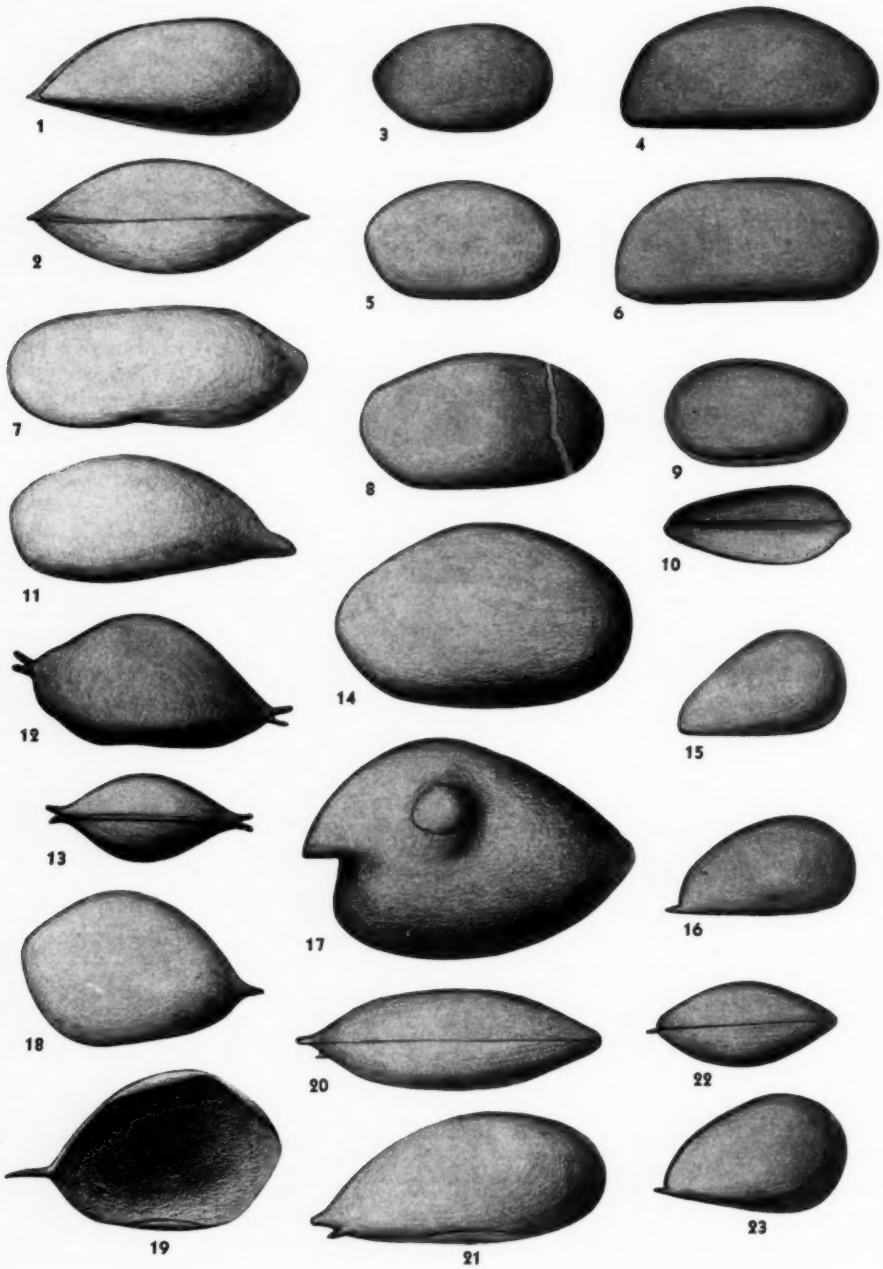
Carapace subrhomboidal in lateral view; ventral margin gently convex, rounding broadly into anterior extremity; dorsal mar-

EXPLANATION OF PLATE 49

FIGS. *1*—*Beyrichiana tumida* Scott and Borgen, n. sp. Holotype, no. X-1268, ×25, right valve. (p. 355)
2, 3—*Monoceratina macoupeni* Scott and Borger, n. sp. Holotype, no. X-1266, ×50, *2*, Right valve. *3*, Dorsal view of right valve. (p. 355)
4, 5—*Monoceratina? nodosa* Scott and Borger, n. sp. Holotype, no. X-1267, ×50. *4*. Dorsal view. *5*, Left valve. (p. 355)
6—*Kirbya punctata* Kellett, ×25, right valve. (p. 354)
7—*Amphissites centronotus* (Ulrich and Bassler), ×25, right valve. (p. 354)
8, 9—*Monoceratina lawrencevillensis* Scott and Borger, n. sp. Holotype, no. X-1270, ×50, right valves. (p. 355)
10, 11—*Bairdia illinoiensis* Scott and Borger, n. sp. Holotype no. X-1277, ×35, *10*, Dorsal view. *11*, Right valve. (p. 357)
12—*Amphissites nodosus* Scott and Borger, n. sp. Holotype, no. X-1269, ×25, right valve. (p. 357)
13, 14—*Bairdia pompilioidea* Harlton, ×25, *13*, Dorsal view. *14*, Right valve. (p. 354)
15, 16—*Discoidella convexa* Scott and Borger, n. sp. Holotype, no. X-1271, ×50. *15*, Right valve. *16*, Probably an internal mold of *Discoidella*. (p. 356)
17—*Bairdia bicornis* Bradfield, ×25, right valve. (p. 354)
18—*Paraparchites* sp? ×25, left valve.
19—*Bairdia garrisonensis* Upson, ×25, left valve. (p. 354)
20—*Bairdia geisi* Kellett, ×50, right valve.
21—*Kirkbya canyonensis* Harlton, ×25, left valve. (p. 354)



Scott and Borger, Pennsylvanian Ostracodes



Scott and Borger, Pennsylvanian Ostracodes

gin strongly convex. Anterior end rounded and greatest extension above the mid-height of the carapace; posterior end sharply acuminate, terminating in a spine slightly below mid-height. Greatest height in anterior half; greatest thickness in the central portion. Carapace moderately thick in dorsal view with evenly tapered ends. Length, 1.00 mm.; width, 0.60 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1276.

Remarks.—*B. wabashensis* is very similar to *B. brevis* Jones and Kirkby. It differs from that species by the greater height of the anterior end, the convexity of the post-dorsal slope, and the spine-like extension of the posterior end.

BAIRDIA QUADRASPINOSA Scott and Borger, n. sp.
Plate 50, figures 12, 13

Carapace subrhomboidal, rather elongate in lateral view; ventral margin gently concave, rounding broadly into the extremities; dorsum strongly convex; anterior beak narrowly rounded and above the mid-height of the valve; posterior beak sharply acuminate, below the mid-height; carapace moderately thick in dorsal view with evenly tapered ends; right valve slightly more convex than the left; greatest height median; greatest thickness median; small spines project out from both valves on both ends at the beaks. Dorsal overlap narrow and even along greatest convexity, increasing toward each beak; overlap indistinct along entire ventral margin, greatest in middle half. Length, 0.55 mm.; height, 0.28 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1275.

BAIRDIA ILLINOIENSIS Scott and Borger, n. sp.
Plate 50, figures 10, 11

Carapace small, sub-ovate; venter broadly convex; dorsum highly arched. Posterior and anterior extremities about mid-height of the shell. The greatest thickness and height is median. Dorsal view elongate ovate; dorsal overlap indistinct at point of greatest convexity, becoming more prominent toward each extremity. The overlap continues posteriorly into a spine-like extension. Two short spines extend from the beak of the anterior end; the spine on the left valve is higher than the one on the right. Ventral overlap is greatest in median portion. Length, 0.82 mm.; thickness, 0.34 mm.; height, 0.40 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1277.

Genus BAIRDIANELLA Harlton, 1929

BAIRDIANELLA ACUTA Scott and Borger, n. sp.
Plate 50, figures 20, 21

Carapace elongate in lateral view, subrhomboidal; dorsum broadly convex; venter straight to broadly convex. Anterior end broadly convex; posterior end extended into

EXPLANATION OF PLATE 50

FIGS. *1, 2—Macrocypris? illinoiensis* Scott and Borger, n. sp. Holotype, no. X-1274, ×50. *1*, Right valve. *2*, Dorsal view. (p. 358)

3, 9, 10—Cavellina nebrascensis (Geinitz), ×25. *3*, Right valve. *9*, Left valve. *10*, Dorsal view. (p. 354)

4—Bythocypris texensis Coryell and Sample, ×50, right valve. (p. 354)

5—Cytherella tongia? Coryell and Sample, ×25, right valve. (p. 354)

6—Bythocypris parallela Knight, ×50, right valve. (p. 354)

7—Bairdia hoxbarensis Harlton, ×25, left valve. (p. 354)

8—Cytherella sp? ×50, right valve.

11—Bairdianella elegans Harlton, ×50, right valve. (p. 354)

12, 13—Bairdia quadraspinosa Scott and Borger, n. sp. Holotype, no. X-1275, ×35. *12*, Left valve. *13*, Dorsal view. (p. 357)

14—Cytherella gloria Coryell and Sample, ×50, right valve. (p. 354)

15, 16, 22, 23—Basslerella unispinosa Scott and Borger, n. sp. Holotype. *22, 23*—no. x-1273, ×50. *15*, Right valve, spine missing. *16*, Right valve. *22*, Dorsal view. *23*, Right valve. (p. 358)

17—Cypridellina triangulata Scott and Borger, n. sp. Holotype, no. X-1272, ×25, right valve. (p. 358).

18, 19—Bairdia wabashensis Scott and Borger, n. sp. Holotype, no. X-1276, ×25, right valves (p. 356)

20, 21—Bairdianella acuta Scott and Borger, n. sp. Holotype, no. X-1278, ×50, *20*, Dorsal view. *21*, Left valve. (p. 357)

a sharp beak resembling a short blunt spine. In dorsal view the carapace is broadly elliptical. A small spine protrudes posteriorly from postero-ventral margin of right valve; prominent ventral overlap in middle half, left valve largest, no apparent dorsal overlap. Length, 0.60 mm.; thickness, 0.18 mm.; height, 0.25 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1278.

Genus MACROCYPRIS Brady

MACROCYPRIS? ILLINOIENSIS
Scott and Borger, n. sp.
Plate 50, figures 1, 2

Carapace elongate in lateral view; dorsum broadly arched; venter slightly convex. Anterior extremity rather narrowly rounded with a long steep antero-dorsal slope and a short ventral slope; posterior extremity sharply pointed. Anterior and posterior ends acuminate in dorsal view, greatest thickness median to slightly posterior of center; surface finely granular; overlap distinct on venter and slight around entire carapace. Length, 0.58 mm.; thickness, 0.21 mm.; height, 0.22 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1274.

Family CYPRIDINIDAE Baird, 1850

Genus Cypridellina Jones, 1873

CYPRIDELLINA TRIANGULATA Scott
and Borger, n. sp.
Plate 50, figure 17

Carapace very large, broadly ovate, highly convex; dorsum rounding evenly into prominent anterior beak with a subjacent notch located at mid-height of the valve; posterior end narrowly rounded to pointed. Large hemispherical node located in antero-dorsal quarter, completely separated from carapace by narrow slit. The separation is due to the absence of the outer layer of the carapace. Shallow, gently curved sulcus posterior to node. The sulcus does not extend to the dorsal margin as in the genus *Cypridella*. Length, 1.34 mm.; height, 0.90 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1272.

Family CYTHERIDAE Baird, 1850

Genus BASSLERELLA Kellett, 1935

BASSLERELLA UNISPINOSA Scott
and Borger, n. sp.
Plate 50, figures 15, 16, 22, 23

Carapace short, subtriangular in lateral view; dorsum broadly angled at point of greatest height just in front of center; venter broad and flat; anterior end broadly rounded; posterior end acute and low. In dorsal view, carapace is thickly ovate, greatest thickness near center, ends tapering rapidly to each extremity; posterior portion of dorsum somewhat flattened with a slightly indented hinge line. Prominent spine projects from post-ventral margin of right valve, extends posteriorly in line with straight venter; overlap prominent along ventral margin. Length, 0.37 mm.; height, 0.23 mm.; thickness, 0.18 mm.

Holotype.—University of Illinois Paleontology collection, no. X-1273.

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JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 4, PP. 359–361, PL. 51, JULY, 1941

NEW ARENACEOUS FORAMINIFERA FROM THE WOODBINE SAND OF NORTHERN TEXAS

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ABSTRACT—Three new species of large arenaceous Foraminifera are described from a sample of Woodbine sand (Upper Cretaceous) from the city of Denison, Grayson County, Texas. Numerous specimens of a new species of *Reophax*, and two new species of *Flabellammina* comprise the faunal assemblage. Polymorphism is well shown by the individuals of *Fabellammina*.

DURING the course of a study of the Foraminifera of the Washita group, uppermost Lower Cretaceous, of northern Texas, samples were also collected from the overlying Upper Cretaceous Woodbine sand, wherever shaly strata were seen. One of these samples contains numerous specimens of three large new species of arenaceous Foraminifera.

The writer is grateful to Dr. J. A. Cushman for reading the manuscript and for checking the species with types at his laboratory. Dr. Carey Croneis aided the writer by reading and checking the manuscript and in making valuable criticisms. The writer also is indebted to Dr. D. J. Fisher for the loan of microscopic equipment used in illustrating the species; to Prof. F. G. Tappan of the University of Oklahoma, and to Dr. Alfred R. Loeblich, Jr. for assistance in the field.

All of the material herein described is from the basal Woodbine clay, below sandy strata, in a roadside ditch on the west side of the road in the 800 block, south Lamar street, just north of East Munson avenue, in the southeast part of the city of Denison, Grayson County, Texas.

Types.—The holotypes and paratypes here figured are deposited at the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts. Paratypes have also been deposited in Walker Museum of Paleontology, University of Chicago, and the Bureau of Economic Geology, Austin, Texas, and in the writer's collection.

[1] Mrs. Alfred R. Loeblich, Jr.

SYSTEMATIC DESCRIPTIONS

Family REOPHACIDAE

Subfamily REOPHACINAE

Genus REOPHAX Montfort, 1808

REOPHAX WOODBINENSIS
Tappan, n. sp.
Plate 51, figures 10a–12

Test large, free, straight, uniserial; chambers numerous, inflated, frequently somewhat compressed, width about twice their height, somewhat irregularly increasing in size as added; sutures distinct, depressed, straight; wall coarsely arenaceous, of angular quartz grains, but with smaller amounts of dark colored minerals, considerable cement, not soluble in acid; aperture terminal, rounded. Length of holotype 1.6 mm., greatest diameter 0.9 mm., least diameter 0.7 mm.; length of compressed and flattened paratype 2.7 mm.; length of larger paratype 4.2 mm., width of last chamber 1.2 mm.

Remarks.—This species is somewhat less abundant than the species of *Flabellammina* in the sample. The holotype is a complete specimen, although not as large as the paratypes. The flattened form is typical of many of the specimens, which are in some cases compressed in such a way as to give a pseudo-biserial appearance. The larger paratype is not complete, the earliest chamber being broken, perhaps still earlier chambers missing. It is also broken across near the middle of the test, but has been figured because it is the largest observed specimen.

Reophax woodbinensis is similar to *R. taxana* Cushman and Waters, but differs in

being about double the size of the latter, in possessing lower chambers which are not as globular, and in having a less coarsely arenaceous test.

Types.—Holotype, Cushman Coll. no. 35205. Paratypes, Cushman Coll. nos. 35206 and 35207; Walker Museum, U. C. no. 48141; and in the Bureau of Economic Geology, Austin, Texas.

Family LITUOLIDAE

Subfamily HAPLOPHRAGMIINAE

Genus FLABELLAMMINA Cushman, 1928

FLABELLAMMINA BRACHYLOCULA
Tappan, n. sp.
Plate 51, figure 9

Test large, free, compressed, elongate, of nearly the same width throughout, early portion coiled, consisting of about four chambers, later portion uniserial, with eight chambers in the holotype, surfaces flat, periphery rounded; chambers slightly inflated centrally, wide and very low; sutures distinct, depressed, very slightly arched; wall coarsely arenaceous, of angular quartz grains with a large percentage of dark colored mineral grains, cement not soluble in acid, surface rough; aperture terminal, narrow, elongate; color yellowish white, with many black or dark-colored grains, in some cases iron-stained. Length of holotype 3.2 mm.; width across last complete chamber 1.8 mm., width through coiled portion 1.4 mm., height of last chamber 0.46 mm.

Remarks.—This species is less abundant than *F. denisonensis*, but is easily distinguished by the less flaring test, larger coiled portion, of about the same width as the uniserial portion, lower chambers, with less arching of the sutures, coarser arenaceous fragments and rougher surface, with a much greater percentage of dark mineral grains. This species is also somewhat similar to *F. longiuscula* Alexander and Smith, differing in the wider and lower chambers, which increase very little in size as added.

Types.—Holotype, Cushman Coll. no. 35208. Paratypes (not figured), Cushman Coll. no. 35209; Walker Museum, U. C. no. 48142; and in the Bureau of Economic Geology.

FLABELLAMMINA DENISONENSIS
Tappan, n. sp.
Plate 51, figures 1–8

Test large, free, elongate, flattened, early portion coiled and composed of four to seven chambers in the microspheric form, large globular proloculum in the megalospheric form, with a faint suggestion of a coil, later portion uniserial, surfaces flat, periphery rounded; chambers numerous, inflated centrally, wide and fairly low, arched gently in the uniserial portion, with as many as eight chambers being seen in the uniserial stage; sutures distinct, depressed, arched; wall coarsely arenaceous, composed largely of angular quartz grains with some other grains, considerable cement, not soluble in acid, giving a nearly smooth surface; aperture narrow, elongate, terminal; color, yellowish white, somewhat iron-stained. Length of holotype (fig. 8), 2.7 mm., width of last

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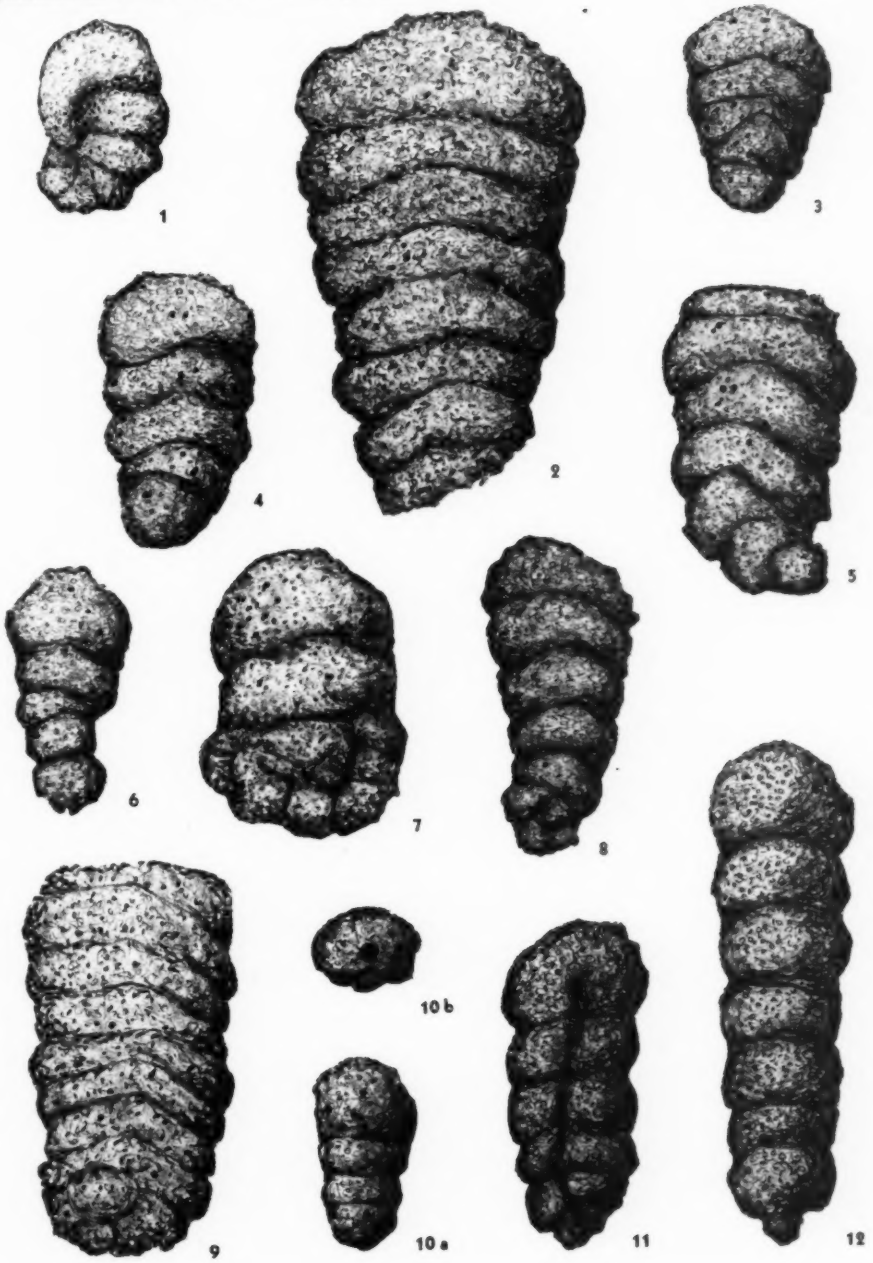
EXPLANATION OF PLATE 51

Illustrations are camera lucida drawings made by the writer. All figures are ×16.

FIGS. *1–8*—*Flabellammina denisonensis* Tappan, n. sp. *1*, Microspheric form with small initial portion. Paratype, Cushman coll. no. 35211; *2*, Probably microspheric form, showing large size attained by this species, early portion broken. Paratype, Cushman coll. no. 35212; *3*, Megalospheric form with large proloculum. Paratype, Cushman Coll. no. 35213; *4*, Megalospheric form with large proloculum. Paratype, Cushman Coll. no. 35214; *5*, Megalospheric form with slight development of coil. Paratype, Cushman Coll. no. 35215; *6*, Megalospheric form with large protoculum. Paratype, Cushman Coll. no. 35216; *7*, Microspheric form, large coiled portion. Paratype, Cushman Coll. no. 35217; *8*, Microspheric form, small coiled portion. Holotype, Cushman Coll. no. 35210. (p. 360)

9—*Flabellammina brachylocula* Tappan, n. sp. Microspheric form, showing large coiled initial portion, nearly parallel sides and low chambers. Holotype, Cushman Coll. no. 35208. (p. 360)

10–12—*Reophax woodbinensis* Tappan, n. sp. *10*, Small complete specimen, *10a*. side view, *b*. top view. Holotype, Cushman Coll. no. 35205; *11*, Compressed form. Paratype, Cushman Coll. no. 35206; *12*, Large specimen, base somewhat broken. Paratype, Cushman Coll. no. 35207. (p. 359)



Tappan, Cretaceous Foraminifera

UNIV. OF MICH.

chamber 1.3 mm., width of coiled portion 0.7 mm. Length of microspheric form of figure 1, 1.6 mm., greatest width 1.1 mm., greatest height of last chamber 0.6 mm. Length of incomplete specimen (fig. 2), 4.2 mm., greatest width of last chamber 2.4 mm., greatest height of last chamber 0.9 mm. Length of megalospheric paratype (fig. 3), 1.75 mm., width of last chamber 1.23 mm., height of last chamber 0.4 mm. Length of megalospheric form (fig. 4), 2.3 mm., width 1.3 mm., height of first chamber 0.75 mm., height of last chamber 0.6 mm. Length of megalospheric specimen (fig. 5), 2.6 mm., greatest width 1.65 mm.; length of megalospheric form (fig. 6), 2.25 mm., width of first chamber 0.6 mm., width of last chamber 1.05 mm., height of last chamber 0.65 mm. Length of microspheric form (fig. 7), 2.4 mm., width of uniserial portion 1.5 mm., width across coiled portion 1.75 mm.

Remarks.—This is by far the most abundant species in the sample and is variable, at least four different types being observed. Microspheric forms may have large coiled portions (fig. 7) or smaller coils (figs. 1 and 8), and the megalospheric forms grade from those with a suggestion of a coil (fig. 5) through intermediate stages (figs. 4 and 6) to a nearly straight type with a large proloculum (fig. 3). The specimen in figure 8 was chosen as the holotype, as it is a microspheric form with both the coiled and uniserial stages well displayed.

Flabellammina denisonensis is similar to *F. magna* Alexander and Smith in size and general characters, but differs in having less arched and lower chambers, which are more regular in size, and a more gradually flaring test. The species is named for the type locality in the town of Denison, Texas.

Types.—Holotype, Cushman Coll. no. 35210. Paratypes, Cushman Coll. nos. 35211 to 35217; Walker Museum, U. C. no. 48143; and in the Bureau of Economic Geology.

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DIDYMOGRAPTUS PROTOBIFIDUS IN NORTH AMERICA

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ABSTRACT—Differentiated first in England and noted in Australia, this Lower Ordovician species first was recognized in America by the writer. It has been secured from four different outcrops in Oklahoma, from Smithville, Arkansas, Marathon, Texas, and from a deep well in the Sand Hills structure of Crane County, Texas. It is thought also that it occurs in the Deepkill of eastern New York. It is purposed to illustrate and describe specimens from each of the American localities, compare them with the British type form, and suggest the stratigraphic importance of the species.

DIDYMOGRAPTUS PROTOBIFIDUS was differentiated, described and illustrated by Elles (1933, pp. 98, 101, 102), and she divided the graptolites of the Skiddaw slates into 5 zones, the third zone into four subzones, and placed the new species in the third subzone. She also noted the presence of intermediate or transient forms between early and later species. The establishing of the zones and subzones and recognition of more specific characteristics have greatly enhanced the value of the group for more accurate correlation. If it were possible to measure the zones and subzones and give the thickness in feet, still further important information would be added. However, the results of this study by Elles have been of great value to those studying identical and similar forms in North America, Scandinavia, and Australia, and they will continue to assist those who study graptolites in any part of the world.

A brief article on the *Didymograptus protobifidus* zone was read before the Society of Economic Paleontologists and Mineralogists at the annual meeting of the Society in Tulsa, 1936, but no manuscript of the article was supplied to the Society.

A brief summary in regard to this zone was published by the writer (Decker, 1936, p. 1255), but since that time further information and more good specimens have been secured.

Grateful acknowledgement is made for assistance in the field to J. O. Beach, Henry Phillips, and Brooks Pierce; to Fred Bush, James Waters and Hugh Eley for supplying graptolites for study, and to Helen Tappan Loeblich for the pencil-shaded drawings, which were made with a Lapworth-Parkes graptolite microscope. Appreciation is also expressed for assistance for field expenses to the Oklahoma Geological Survey, the Oklahoma University Research fund and to the American Association for the Advancement of Science, through the Oklahoma Academy of Science, for a grant to meet part of the expenses of preparing the material for publication.

SYSTEMATIC DESCRIPTIONS

Class GRAPTOLITHINA Bronn, 1846
Order GRAPTOLOIDEA Lapworth, 1875
Family DICHOGRAPTIDAE Lapworth, 1873
Genus DIDYMOGRAPTUS McCoy, 1851
DIDYMOGRAPTUS PROTOBIFIDUS Elles, 1933
Plate 52, figures 1–9; plate 53, figures 1–15

Didymograptus protobifidus was differentiated, described and illustrated by Elles

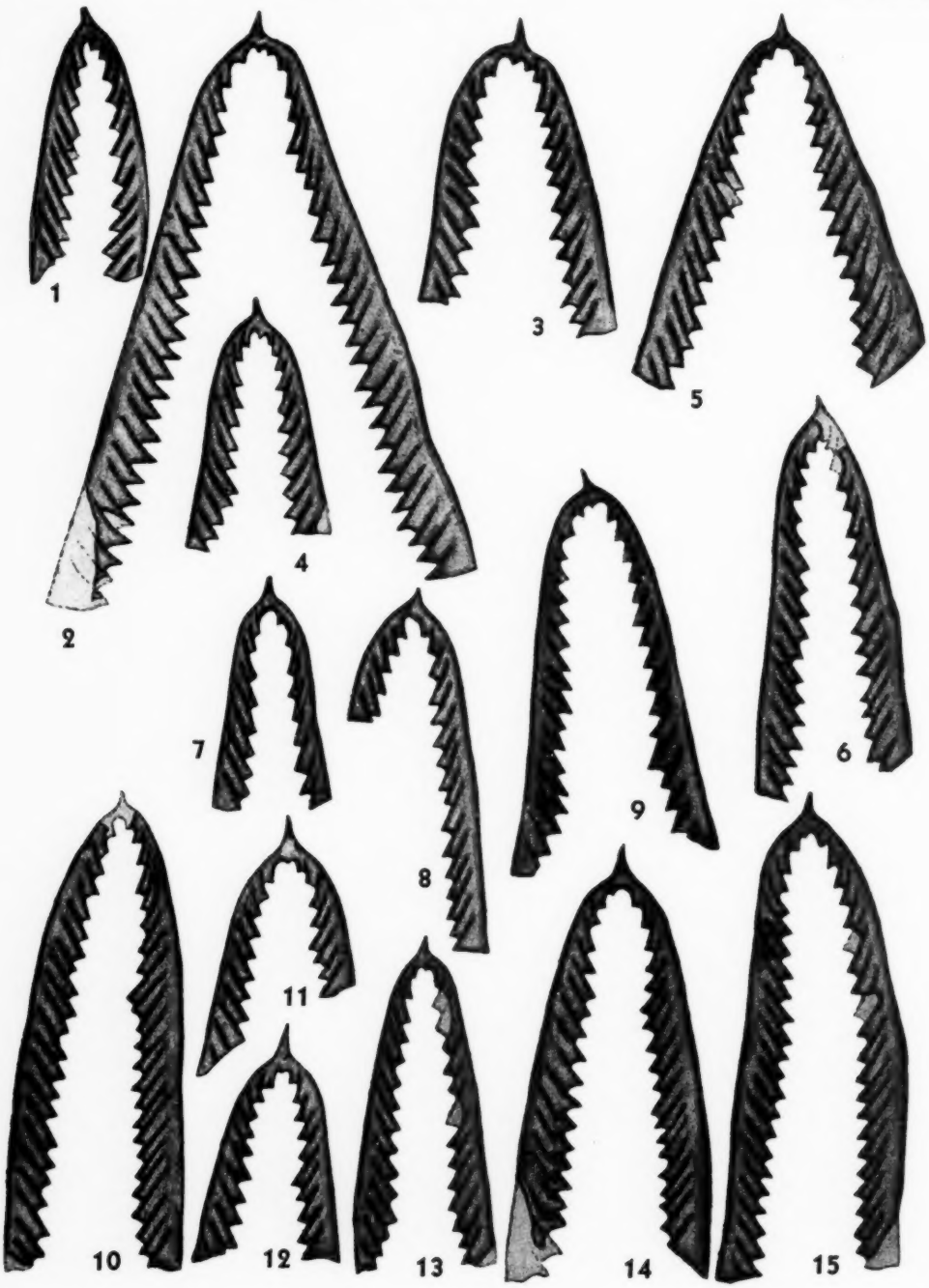
EXPLANATION OF PLATE 52

All figures are ×4. The ideotypes (homeotypes) noted below are in the Museum of Invertebrate Paleontology, University of Oklahoma, Norman, Oklahoma. All specimens *Didymograptus protobifidus.*

FIGS. *1–4*—U. S. Highway 77, Arbuckle Mountains, Oklahoma. *1*, transient; *2–4*, *Didymograptus protobifidus. 1–4*, A 2001a–A 2001d.

5–9—North Crusher Quarry, Arbuckle Mountains Oklahoma. *5* and *9* are typical *D. protobifidus*; *6*, *7*, and *8* are transients. *5–9*, A 2002a–A 2002e.

Decker, Ordovician Graptolite



Decker, Ordovician Graptolite

(1933, p. 98, 110, figs. 1–3). Her original description is as follows:

> Rhabdosome commonly small, stipes ranging from 1–2 cm. in length, narrow at origin, and increasing very slightly in width to a maximum of 1.3 mm., either running parallel or diverging in the manner of *D. bifidus*. Sicula conspicuous, slender. Thecae 13 in 10 mm., free ⅓ their length, inclined at a low but variable angle, slightly curved distally, with apertural margins slightly oblique to the general direction of the stipe.

Miss Elles indicated that the species and its transients had been included under *D. nanus* Elles (1901, Pl. 4, figs. 5d, species, 5f, and h, transients). She says:

> It is however distinct in several particulars; the width of the stipes is less uniform than in *D. nanus*, and the thecae are differently set, so that not only are they more numerous in a given unit of length, but the apertural margins are oblique to the general direction of the stipe instead of being perpendicular as they are in *D. nanus* and *D. indentus*, and occupy a small portion of the total width. The thecae are essentially the same type as those seen in the young stages of *D. bifidus*, but they never attain the curvature or degree of overlap seen in the mature thecae of *D. bifidus* or its ally *D. artus*.

Miss Elles indicates that the species occurs at many localities, and ranges from middle to upper Skiddaw slates.

As to the figures shown by Elles (1933, p. 110, figs. 1–3), the specimens must have been poorly preserved, as she gives no details of the form of the thecae, and if figure 1 represents a normal form, it is ⅛ too narrow. The width shown is only 3.3 instead of 3.9 mm. and this makes it a little more difficult to compare with the American forms. In figures 2 and 3 by Elles, differences in width are clearly shown by differences in the mode of preservation. Most of the American forms are well preserved, so that the thecae can be shown and some of them are spread out very flat, resulting in an apparent increase in the width of the stipes.

As noted above, *Didymograptus protobifidus* has been found in four localities in Oklahoma. The first of these is on U. S. Highway 77, sec. 19, T. 2 S., R. 2 E., 808 feet below the top of the West Spring Creek, the uppermost formation of the Arbuckle group. This zone is about 3800 feet above the lower Arbuckle dendroid graptolite zone, about 900 feet below the *D. bifidus—artus* zone in the Joins formation, near the base of the Simpson group, and about 3000 feet below the *Diplograptus* (*Amplexograptus*) *maxwelli—Dicellograptus mensurans* zone near the top of the Bromide formation in the upper Simpson.

The *D. protobifidus* zone on U. S. Highway 77 extends through about 5 feet of very thin limestones, ½ inch to an inch in thickness, separated by thin films of shale, but most of them are concentrated in the upper two inches of the zone. In studying recently a large number of forms, a few typical *D. protobifidus* were found 37 feet below the regular concentrated zone, and one was found 70 feet above it, so they seem now to have a recognized vertical range of a little over 100 feet. In this concentrated zone transients occur which increase more in width and have greater thecal overlap than *D. protobifidus*, for which the thecal number is 13 in 10 mm. In a zone 37 feet lower, *D. protobifidus praecursor* Monsen (1937, p. 152) occurs with nine to 11 thecae in 10 mm., and this zone with the *praecursor* variety has been discovered in the Wichita Mountains.

On plate 52, figures 1–4 are from U. S. Highway 77 and 5–9 from the North Crusher Quarry. Figure 1 seems clearly to represent a transient because of its increase in width

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EXPLANATION OF PLATE 53

All figures are ×4. The ideotypes (homeotypes) noted below are in the Museum of Invertebrate Paleontology, University of Oklahoma, Norman, Oklahoma. All specimens *Didymograptus protobifidus*.

FIGS. *1–4*—South Crusher Quarry, Arbuckle Mountains, Oklahoma. *1*, *3*, and *4* are *Didymograptus protobifidus; 2*, a transient. *1–4*, A 2003a–A 2003d.

5–6—Grayson Mine near Smithville, Arkansas. *5*, a transient; *6*, *Didymograptus protobifidus*. *5–6*, A 2004a–A 2004b.

7–8—*Didymograptus protobifidus*, east side of Washita River, Arbuckle Mountains, Oklahoma. *7–8*, A 2005a–A 2005b.

9—*Didymograptus protobifidus*. Gulf Oil Corp., McKnight no. 3, Crane Co., Texas. A 2006.

10–15—Marathon region, Texas. *11*, *12*, *13*, *Didymograptus protobifidus; 10*, *14*, *15*, transients. *10–15*, A 2007a–A 2007f .

and considerable amount of thecal overlap. Figures 2–4 are more typical of the species, though the thecal overlap is more than ½ in both 2 and 3.

Of the specimens from the north quarry, figures 5 and 9 have characteristics closer to those of *D. protobifidus* and figures 7 and 8 are clearly transients which increase considerably in width and have as much as ¾ thecal overlap. Figure 6 not only has large thecal overlap but also has 14 thecae in 10 mm.

On plate 53, figures 1–4 are from the South Crusher Quarry; 5–6 from near Smithville, Arkansas; 7–8 from the east side of the Washita River, south of Crusher; 9 from a deep well in Crane County, Texas; and 10–15 from the Marathon region of Texas.

Of the forms from the north side of the South Crusher Quarry, figures 1, 3 and 4 seem to conform more nearly to the characteristics of *D. protobifidus*, while figure 2, a transient, increases too much in width and has too great thecal overlap for the species.

Figures 5 and 6 are from the abandoned Grayson mine near Smithville, Arkansas, 5 is a transient and 6 is *D. protobifidus*.

The specimens from the east side of the Washita River shown in figures 7 and 8 occur at the same horizon and in a zone similar to the one on U. S. Highway 77. The zone is about 10 feet wide and consists of very thin limestones separated by films of shale and most of the graptolites are near the top of the zone. Because of the more rapid weathering of the thin beds, a deep chute with nearly vertical walls has been eroded into the face of the steep cliff. From this zone the forms represented in figures 7 and 8 both have *D. protobifidus* characteristics.

The specimens from northeastern Arkansas are from the abandoned Grayson Mine, 5 miles northwest of Smithville, in the western edge of Lawrence county. There is a great pile of light gray limestone near the opening of the old mine, and the graptolites are found scattered through these limestone blocks. The dependent graptolites *D. protobifidus* occur with extensiform transients of the *D. nitidus-hirundo* type and with *Phyllograptus anna*. The Arkansas forms are shown in figures 5 and 6 on Plate 53 The latter seems to be a characteristic *D. protobifidus* but figure 5 is a transient with too great increase in width and too much overlap of thecae.

Among the forms shown in plate 53 from the Marathon region of Texas, figures 11, 12, 13 are *protobifidus*-like, but in figures 10, 14, and 15 the overlap of thecae is too great. The dependent graptolites in this region are associated with extensiform *Didymograpti* and with *Phyllograptus anna*.

It is of great interest that a typical *D. protobifidus*, shown in figure 9 of Plate 53 was secured from a deep well in Crane County, Texas, about 100 miles north of Marathon. It was found in a core by M. E. Upson of the Gulf Oil Corporation, in the McKnight well No. 3, on the Sand Hills Arch, at a depth of 6092–93 feet. A brief description of the Sand Hills structure and the location of this well has been shown by C. D. Cordry (1937, pp. 1575–1579). This zone seems to correspond with one 808 feet below the top of the West Spring Creek, the uppermost formation of the Arbuckle group in Oklahoma.

In the Deepkill of eastern New York, it is thought that *D. protobifidus* and its transients should occur rather than *D. bifidus*, because of the association with *Tetragrapti* and *Phyllograpti* in the Deepkill. *D. protobifidus* occurs both in Australia (Keble and Harris, 1934, p. 169) and in Great Britain (Elles, 1933, p. 101) with *Tetragrapti* and *Phyllograpti*. In Great Britain, *D. bifidus* occurs higher and is separated from the *D. protobifidus* zone by two intermediate graptolite assemblages, while in Oklahoma the *D. protobifidus* occurs about 900 feet below the *D. bifidus artus* zone.

Among the many beautifully preserved dependent graptolites of Sweden, Ekström (1937, p. 30, pl. 6, figs. 1–6) did not recognize the presence of *D. protobifidus*, but he did describe as a new species a closely similar, though narrower, form, *D. obscurus*.

In the very prolific Lower Ordovician graptolite horizon in Norway, Monsen (1937 p. 152, pl. 9, fig. 10; pl. 10, figs. 13–15, table 3, figs. 18, 34) recognized an earlier form of *D. protobifidus* to which he gave a new variety name of *praecursor*, which is characterized by having two to four less thecae in 10 mm. than the typical *D. protobifidus*. As noted above, this *praecursor* variety has been found in Oklahoma, both on U. S. Highway 77, in the Arbuckle Mountains,

and on the north side of the Wichita Mountains.

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ARENACEOUS FORAMINIFERA FROM THE NIAGARAN ROCKS OF OHIO AND INDIANA

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ABSTRACT—Arenaceous foraminifera recovered during a study of insoluble residues from Niagaran rocks of Ohio and Indiana are herein described. Specimens were found in the Dayton limestone, Osgood shale, and Massie shale of Ohio, and in the Osgood formation and Laurel limestone of Indiana. Twenty-one species have been recognized, ten of which represent previously undescribed forms. Twenty species belong in the more primitive families including the Astrorhizidae, Rhizamminidae, Stegnamminidae, Saccamminidae, and Ammodiscidae. One species belongs in the more complex family Trochamminidae, a family previously not known in pre-Pennsylvanian strata.

DURING the course of a laboratory study by the junior author on insoluble residues from the Niagaran rocks of southwestern Ohio and southeastern Indiana (Priddy, 1939), considerable fossil material, even to the extent of several percent of the sample, was found in some of the residues. The fossils, which for the most part are confined to the shale and shaly limestone units, consist of either the siliceous remains of organisms, or organisms replaced by silica, pyrite, or glauconite. The siliceous organisms and silica replacements are by far the most abundant, and include sponge spicules, minute crinoid stems, very small *Tentaculites*, casts of tiny gastropod shells, and Foraminifera. The sponge spicules and the Foraminifera are the most abundant fossils observed.

The Foraminifera are of special interest because so far as the writers know this is the first occurrence that has been recognized in the Niagaran rocks of either Ohio or Indiana. Since the discovery by Moreman in 1930 of undoubted Foraminifera in rocks of Ordovician and Silurian age in Oklahoma, several occurrences of pre-Carboniferous Foraminifera have been reported from elsewhere in North America. Silurian species have been reported from southeastern Missouri and near Joliet, Illinois, by Croneis, Dunn, and Hunter (1932), and from the Chicago area by Grubbs (1939). We are now able to report yet another locality from which Silurian forams have been collected.

The Niagaran rocks from which the specimens included in this study were obtained outcrop on the flanks of the Cincinnati arch in southeastern Indiana and southwestern Ohio. The area of outcrop is a relatively narrow belt extending from Charlestown, Clark County, Indiana, northward to the vicinity of Richmond and thence eastward to Cedarvillle, Greene County, Ohio. The boundary of the Niagaran rocks is shown in figure 1.

The generally accepted classification of the Niagaran rocks of this region, modified slightly by the field work of the junior author, is as follows:

Southeastern Indiana	*Southwestern Ohio*
	Cedarville dolomite
	Springfield dolomite
	Euphemia dolomite
Waldron shale	Massie shale
Laurel limestone	Laurel limestone
Osgood formation	Osgood shale
Basal Osgood limestone	Dayton limestone

Lithologically the rocks consist of several limestone and dolomite formations, with some argillaceous material present in a few relatively thin shale units. The various formations are comparatively easily distinguished from each other because of distinct lithologic differences. Further, they possess enough variation within themselves to permit a more detailed stratigraphic separation into zones. In the field the zones have been established by the color of the fresh rock, the color when weathered, the amount of

crystallization, texture, relative hardness, and bedding. In the laboratory a detailed petrographic and mineralogical study was made by means of thin sections, insoluble residues, and powdered material in order to evaluate the importance of minerals in stratigraphic and paleogeographic studies. In the process of this work the Foraminifera came to light.

The zones thus established both by field and laboratory examination are shown in Table 1 (Priddy, 1939, p. 494).

TABLE 1.—LITHOLOGIC ZONES

Indiana	
Laurel limestone	Thickness in feet
Zone G. Dense, cherty limestone	4–10
Zone F. Coarsely crystalline limestone	0–16
Zone E. Dense, rather shaly limestone	0–10
Zone D. Dense, cherty limestone	0– 8
Zone C. Dense, rather shaly limestone	3–15
Zone B. Coarsely crystalline, vuggy limestone	9–15
Zone A. Dense, shaly limestone	0–18
Osgood formation	
Zone F. Upper, shaly limestone	1– 2
Zone E. Upper shale	1– 5
Zone D. Middle, shaly limestone	0– 5
Zone C. Middle, coarsely crystalline limestone	0– 3
Zone B. Lower shale	0– 8
Zone A. Lower shaly limestone (Dayton)	0– 8
Ohio	
Cedarville dolomite	
Upper, coarsely crystalline, vuggy dolomite	10–45
Lower, coarsely crystalline, vuggy dolomite	10–15
Springfield dolomite	
Upper, finely crystalline, vuggy dolomite	4– 8
Lower, finely crystalline, vuggy dolomite	2– 8
Euphemia dolomite, coarsely crystalline, vuggy	3–11
Massie shale	5– 6
Laurel limestone, dense, rather shaly	5– 8
Osgood shale	3–25
Dayton limestone	
Upper, dense, shaly limestone	4– 5
Lower, dense, shaly limestone	4– 5

As a result of the earlier study by the junior author it has been shown that the lower part of the Dayton limestone of Ohio is equivalent to the entire Dayton limestone of Indiana; the Osgood shale of Ohio is equivalent to the upper shale (zone E) of the Osgood formation of Indiana; and the Laurel limestone of Ohio represents only zone E of the Laurel of Indiana.

Occurrence of Foraminifera.—All of the Foraminifera found are of the arenaceous type, having the test composed of well agglutinated, fine, white sand. The cementing material is apparently siliceous since it has survived the acid treatment to which all the samples were submitted. The tests are commonly very fragile, and for that reason probably numerous specimens were destroyed during the process of preparing the residues for study.

Foraminifera were found in Ohio in the Dayton limestone, Osgood shale, and Massie shale, and in Indiana in the Osgood formation and Laurel limestone. In point of abundance and variety they are most common in the Osgood formation of Indiana, for of the 21 species recognized 16 are represented in the Osgood. The other formations contain Foraminifera as follows: in Indiana six species in the Laurel limestone; in Ohio four species in the Dayton limestone, six in the Osgood shale, and two in the Massie shale.

While some species are represented in our collections by only one or two specimens, others, such as *Ammodiscus exsertus*, *A. incertus*, and *Lituotuba exserta*, occur in relative abundance. Likewise these three species are the most widespread in distribution. *Ammodiscus exsertus* is the most abundant form, making up nearly one-half of one percent of the residues from the Dayton limestone at several localities in Ohio and Indiana. *A. incertus* is second in abundance, and is most common in the residues of zone A of the Laurel limestone at Charlestown Landing, Indiana.

Of the 21 species here described 20 belong to the more primitive families of Foraminifera including the Astrorhizidae, Rhizamminidae, Stegnamminidae, Saccamminidae, and Ammodiscidae, while only one species belongs in the more complex family Trochamminidae. This latter species has been placed provisionally in the genus *Trochammina* which is the most primitive genus of the family recognized up to the present time. Since *Trochammina* has not been found previously in pre-Pennsylvanian strata it may well be that this Ohio species more rightly belongs in a still more primitive genus of the family. Until more specimens are obtained its appropriate place in the

family Trochamminidae cannot be definitely determined.

Ten new species are here recognized in the Foraminifera recovered from the residues. Of the remainder, one, *Thurammina* sp., may be a new form, while the others have been recognized before in the Silurian rocks of the Mississippi valley. The fauna closely resembles that of the Chimney Hill formation of Oklahoma, since nine of the remaining ten species occur in that formation. The Chimney Hill is generally regarded as Brassfield in age. Moreman (1933, p. 393) states that the Henry House formation, which is Niagaran in age, contains species identical with those in the Chimney Hill formation. He states however that not a single species from the Viola formation, Upper Ordovician, has been found in the Chimney Hill. One species from the Laurel limestone of Indiana has been identified as *Bathysiphon exiguus* Moreman, a Viola form. However, since the specimens are not identical to Moreman's this identification may be open to question.

The drawings used for the plates were made by E. G. Mason, graduate student in the Department of Fine Arts, Ohio State University. The camera lucida was used for the outline of the specimens.

TABLE 2.—DISTRIBUTION OF SPECIES IN NIAGARAN UNITS OF OHIO AND INDIANA

Species	Ohio							Indiana	
	Dayton ls.	Osgood sh.	Laurel ls.	Massie sh.	Euphemia dolo.	Springfield dolo.	Cedarville dolo.	Osgood fm.	Laurel ls.
Ammodiscus exsertus Cushman	×	×						×	
Ammodiscus incertus (d'Orbigny)	×	×						×	×
Bathysiphon curvus Moreman								×	×
Bathysiphon deminutionis Moreman								×	×
Bathysiphon exiguus Moreman									×
Lituotuba exserta Moreman	×	×						×	×
Lituotuba inflata Ireland	×								
Marsipella? torta, n. sp.								×	
Psammosphaera cava Moreman		×						×	
Psammosphaera subsphaerica, n. sp.				×					
Raibosammina irregularis, n. sp.								×	
Rhabdammina geniculata, n. sp.								×	
Rhabdammina minuta, n. sp.								×	
Rhabdammina triradiata, n. sp.								×	
Saccammina aspera, n. sp.									×
Sorosphaera osgoodensis, n. sp.		×		×				×	
Thurammina arcuata Moreman								×	
Thurammina crescentrica, n. sp.								×	
Thurammina elliptica Moreman								×	
Thurammina sp.								×	
Trochammina? prima, n. sp.		×							

The drawings used for the plates were made by E. G. Mason, graduate student in the Department of Fine Arts, Ohio State University. The camera lucida was used for the outline of the specimens.

DESCRIPTION OF LOCALITIES

Indiana

1. Charlestown Landing ravine section, Clark county, overlooking Ohio River, three and one-half miles southeast of the village of Charlestown, Indiana. This is the most southerly complete development of the Laurel formation where the entire 40 feet of the limestone is exposed overlying conformably the crumpled Osgood beds, and overlain disconformably by the Waldron shale.

2. Fourteen Mile Creek section, Clark county, three miles northeast of the village of Charlestown, Indiana, where the Charlestown-New Washington road (abandoned Indiana highway 62) crosses the deep valley of Fourteen Mile Creek. About 24 feet of shale and limestone of the Osgood formation are exposed beneath the bridge.

3. Madison Hill section, Jefferson county, one and one-half miles west of Madison, Indiana, at the junction of state highways 56 and 62. This is near the crest of the long road cut which exposes about 200 feet of upper Richmond beds, Brassfield limestone, Osgood formation, and Laurel limestone. About 25 feet of the Osgood, and 24 feet of Laurel are exposed.

4. Butlerville quarry section, Jennings county,

two miles northwest of the village of Butlerville in eastern Jennings County, adjoining a small creek one-half mile north of the State Hospital buildings. The entire thickness of Laurel limestone, 42 feet, is exposed.

5. Hutchinson Creek section, Decatur county, six miles south and one mile east of Greensburg, Indiana. Approximately nine feet of Osgood formation are exposed in the wall of Cobbs Fork, one-fourth mile west of the junction of the north and south branches of the stream, and 26 feet of the Laurel limestone in Hutchinson quarry at the highway bridge over the south branch.

6. Andersonville section, Franklin county, on Salt Creek and in the adjacent George quarry, immediately north of U. S. highway 52, one and one-half miles southeast of Andersonville, Indiana. In the stream bed are exposed 9 feet, 7 inches of the Osgood formation, and 3 feet of the Laurel limestone. In the quarry walls are exposed 18 feet of the Laurel limestone.

Ohio

7. Lewisburg quarry section, Preble county, one mile north of Lewisburg, Ohio. The quarry walls expose 48 feet of Niagaran strata, which includes six units, from the base of the Dayton limestone to the basal 15 feet of the Cedarville dolomite.

8. Covington region, Miami county, from 52 to 60 feet of Niagaran strata are exposed from the base of the Dayton limestone through the lower 20 feet of the Cedarville dolomite.

9. Ludlow Creek section, Miami county, just west of Ludlow Falls, Ohio. For a distance of one mile the valley walls expose 28 feet, 10 inches of Niagaran strata including the Dayton limestone, Osgood shale, Laurel limestone, and the Euphemia, Springfield, and Cedarville dolomites.

10. Bryan State Park section, Green county, in Bryan State Park on the west bank of the Little Miami River, one and one-half miles southeast of Yellow Springs, Ohio. The section exposes 44 feet of Niagaran strata from the upper Osgood shale through the basal ten feet of the Cedarville dolomite in the rock cut of a new roadway and a small ravine one hundred feet south.

11. Massie Creek section, Greene county, in lower west end of the one mile gorge immediately west of Cedarville, Ohio. Forty feet of Niagaran strata are exposed including the upper Laurel limestone, Massie shale, and the Euphemia, Springfield, and Cedarville dolomites.

SYSTEMATIC DESCRIPTIONS

Family ASTRORHIZIDAE

RHABDAMMINA GENICULATA Stewart and Priddy n. sp.
Plate 54, figure 1

Test free, of medium size, consisting of two tubular chambers at an angle to one another; walls thick, composed of fine firmly cemented sand grains; exterior rough; circular apertures at the open ends of the arms; color white.

Length of arms, which are about equal, 0.42 mm.

The shape distinguishes this form from other species of the genus.

Occurrence.—In a 24-inch shaly limestone layer of the Osgood limestone (zone F) at locality 3.

Holotype.—No. 18822, Geological Museum, Ohio State University.

RHABDAMMINA MINUTA Stewart and Priddy, n. sp.
Plate 54, figure 2

Test free, small, consisting of three branches radiating from a central area, one of which is much shorter than the others, and may be broken; all three appear to be widest at the free end; walls thick, composed of fine, firmly cemented sand grains; exterior rough; a minute aperture can be seen at the end of one arm, and, although not detected, there probably is one at the end of each of the other arms.

Measurement of longest arm 0.35 mm., and of shortest 0.15 mm.

This form differs from *Rhabdammina geniculata* in the smaller size, and in having the branches more nearly in a plane and not so irregularly constricted.

Occurrence.—Zone D, shaly middle limestone layer of the Osgood formation of Indiana, at locality 2.

Holotype.—No. 18823, Geological Museum, Ohio State University.

RHABDAMMINA TRIRADIATA Stewart and Priddy, n. sp.
Plate 54, figure 3

Test free, of medium size, consisting of three irregular arms branching from a central area; two of the arms thicker at the free end, one of which shows the beginning of another branch; one of the arms is considerably longer than the others and has several constrictions; walls thick, composed of fairly coarse, firmly cemented sand grains; exterior rough; a minute circular aperture at the end of each arm.

The longest arm, which is irregularly curved, measures 0.95 mm. in length, and the shortest which is also curved and probably broken measures 0.44 mm.

This species resembles *Rhabdammina trifurcata* Moreman from the Viola formation

(Ordovician) of Oklahoma, but the tubes are much more irregular both in diameter and manner of branching.

Occurrence.—Zone D, shaly middle limestone layer of the Osgood formation of Indiana, at locality 2.

Holotype.—No. 18824, Geological Museum, Ohio State University.

Family RHIZAMMINIDAE

MARSIPELLA? TORTA Stewart and Priddy, n. sp.
Plate 54, figure 4

Psammonyx sp. PRIDDY, *1939*, Jour. Geology, vol. 47, no. 5, p. 496.

Test of medium size, apparently free, consisting of an irregularly curved, somewhat compressed single, tubular chamber increasing in diameter slightly towards one end which is open and apparently serves for the aperture; wall thick, composed of fine, firmly cemented sand grains of variable size; surface rough and pitted; color white.

Length of figured specimen 0.63 mm., diameter of larger end of tube 0.11 mm.

The generic position of this species is questionable. It is more irregularly coiled than is common for the genus, and the wall is composed entirely of sand grains with no evidence of sponge spicules. In most species of the genus *Marsipella* sponge spicules are used commonly for wall material.

Occurrence.—Zone E, upper shale of the Osgood formation of Indiana, at locality 1.

Holotype.—No. 18825, Geological Museum, Ohio State University.

BATHYSIPHON CURVUS Moreman
Plate 54, figure 5

Bathysiphon curvus MOREMAN, *1930*, Jour. Paleontology, vol. 4, p. 45, pl. 5, figs. 9, 10. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Moreman's description of this species is as follows:

Test free, cylindrical, curved and distinctly tapering, in some specimens very slightly constricted at intervals; wall thin, composed mostly of very fine sand firmly cemented, surface smooth; apertures at the open ends of the tubes; color white.

The two or three specimens referred to this species have rough exteriors rather than smooth ones. The largest specimen measures 1.5 mm. in length.

Occurrence.—Zone C of the Laurel limestone of Indiana, locality 1; zone F, upper shaly limestone of the Osgood formation of Indiana, locality 5.

Hypotype.—No. 18826, Geological Museum, Ohio State University, zone C of the Laurel limestone at locality 1.

BATHYSIPHON DEMINUTIONIS Moreman
Plate 54, figure 6

Bathysiphon deminutionis MOREMAN, *1930*, Jour. Paleontology, vol. 4, p. 46, pl. 5, fig. 6. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Moreman describes this form as follows:

Test free, cylindrical, curved, only slightly tapering, externally constricted; wall thin, composed of fine sand firmly cemented, surface smooth but uneven due to the constrictions; the test rapidly diminishes in diameter at each end so that the apertures are considerably less in diameter than the remainder of the test; color white.

The three or four Ohio specimens which have been identified with this species do not have the test notably constricted; and only one appreciably diminishes in diameter at both ends. The figured specimen measures length 0.61 mm., diameter, midway between ends, 0.12 mm.

Occurrence.—In the lower 18 feet (zones A and B) of the Laurel limestone of Indiana, at locality 1; and the 24-inch shaly limestone layer of the lower limestone (zone F) of the Osgood formation, at locality 3.

Hypotype.—No. 18827, Geological Museum, Ohio State University, zone F of the Osgood formation at locality 3.

BATHYSIPHON EXIGUUS Moreman
Plate 54, figure 7

Bathysiphon exiguus MOREMAN, *1930*, Jour. Paleontology, vol. 4, p. 46, pl. 6, fig. 8. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Moreman describes this species as follows;

Test free, cylindrical, slightly tapering, straight and very small; wall thin, composed of fine sand firmly cemented, surface smooth; apertures at the open ends of the tubes; color white.

A few specimens are referred with some question to this species. They are somewhat larger, and the wall seems to be thicker than in Moreman's specimens. Two specimens have the following dimensions; length 0.87 mm., diameter 0.17 mm.; length 0.45 mm., diameter 0.05 mm.

Occurrence.—In the lower 18 feet (zones A and B) of the Laurel limestone of Indiana, at locality 1; in the 4-foot limestone layer (zone D) of the Osgood formation of Indiana, at locality 2.

Hypotype.—No. 18828, Geological Museum, Ohio State University, zone A, Laurel limestone at locality 1.

Family STEGNAMMINIDAE Moreman

Subfamily PSAMMOSPHAERINAE Cushman

PSAMMOSPHAERA CAVA Moreman
Plate 54, figures 8, 9

Psammosphaera cava MOREMAN, *1930* Jour Paleontology, vol. 4, p. 48, pl. 6, fig. 12. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Test free, thin and fragile, spherical in outline; wall composed of clear quartz grains, rather large for the size of the specimen, little cement; no apparent aperture; color white.

Diameter of figured specimen 0.30 mm. Other specimens are smaller.

Several specimens of this form have been recognized, most of which are partly broken due to the fragile condition of the wall. They are somewhat smaller than the Chimney Hill specimens but appear to be similar in all other respects.

Occurrence.—In the lower 15 inches of the lower limestone (zone A) of the Osgood formation of Indiana, at locality 3; in zones B and C of the Osgood formation at locality 2; upper 12-inch shale (zone C) of the Osgood formation, at locality 5.

Hypotypes.—Nos. 18829, 18830, Geological Museum, Ohio State University. No. 18829 from zone A of the Osgood formation, at locality 3; no. 18830, from zone C of the Osgood formation, at locality 2.

PSAMMOSPHAERA SUBSPHAERICA
Stewart and Priddy, n. sp.
Plate 54, figure 10

Test free, globular; sub-spherical; wall composed of very fine sand grains of uniform size with much cement; surface smooth; two slight projections occur on opposite sides of the test which do not appear to have open ends; no apertures visible; white in color.

Diameter of figured specimen 0.39 mm.

Only one specimen of this species has been found. It resembles *P. gracilis* Ireland but the shape is different. The specimen is larger, and has two minute projections which *P. gracilis* lacks.

Occurrence.—In the Massie shale of Ohio, at locality 11.

Holotype.—No. 18831, Geological Museum, Ohio State University.

SOROSPHAERA OSGOODENSIS Stewart and Priddy, n. sp.
Plate 54, figure 11

Sorosphaera sp. PRIDDY, *1939*, Jour. Geology, vol. 47, no. 5, p. 496.

Test free, consisting of five or more plano-convex chambers in the same plane, firmly cemented to one another, apparently without direct communication; wall distinct, thin, composed of minute sand grains approximately the same size and held together with much cement which is perforated by tiny pores. In one of the specimens examined an opening occurs at the junction of the chambers in the middle of the aggregate on the flat side. This may represent an aperture although it does not appear to open directly into any of the chambers; surface smooth; milky and translucent in color.

The fact that one side of the test is flat suggests that this form may have been attached. Average diameter of individual chambers in the two specimens studied 0.25 mm.

A species of this genus previously reported from rocks of Silurian age is *Sorosphaera tricella* Moreman (1930), from the Chimney Hill limestone (Brassfield age), near Bromide, Oklahoma. The same species was also reported by Croneis, Dunn and Hunter (1932) from the Bainbridge limestone (Niagaran) of southeastern Missouri. *S. osgoodensis* differs from *S. tricella* in the greater number of chambers, and in having one side flat.

Only two complete specimens have been examined, one of which has five chambers and the other six.

Occurrence.—This form was found sparingly in the residues of the Osgood (zone A) and Massie (zone C) shales of Ohio at locality 10, and the residue of zone E, Osgood shale of Indiana, at locality 6.

Our species may more appropriately be referred to *Sorosphaera multicella* Dunn but in the absence of a published description of

Dunn's species it is impossible to say. The species was mentioned by Ireland (1939).

Holotype.—No. 18832, Geological Museum, Ohio State University, zone C of the Massie shale, at locality 10.

Subfamily STEGNAMMININAE

RAIBOSAMMINA IRREGULARIS Stewart and Priddy, n. sp.
Plate 54, figure 12

Test probably attached, of medium size, consisting of a tubular, irregularly curved chamber, compressed, diameter greatest in the middle portion and decreasing to both ends; wall uneven in thickness, consisting of firmly cemented sand, of variable size; surface rough and pitted; no apparent aperture; color white.

Measurements of figured specimen are length 1.3 mm., greatest diameter 0.20 mm.

This species differs from *R. mica* Moreman and *R. aspera* Moreman from the Viola limestone of Oklahoma in shape, and in having the greatest diameter in the middle of the test.

Occurrence.—Zone E, upper shale of the Osgood formation of Indiana, at locality 1.

Holotype.—No. 18833, Geological Museum, Ohio State University.

Family SACCAMMINIDAE

Subfamily SACCAMMININAE

SACCAMMINA ASPERA Stewart and Priddy, n. sp.
Plate 54, figure 13

Test apparently free, sub-spherical, consisting of a single chamber extended at one place into a short neck at the end of which is a circular aperture; wall thick, composed of coarse sand grains firmly cemented but with little cement; exterior rough; color white.

Diameter of figured specimen 0.32 mm.

In general appearance this species resembles very closely *S. moremani* Ireland from the Chimney Hill limestone of Oklahoma, but the sand grains are certainly coarser when compared with the size of the specimen, and the neck is narrower.

Occurrence.—Zone B, lower limestone member of the Laurel, at locality 4.

Holotype.—No 18834, Geological Museum, Ohio State University.

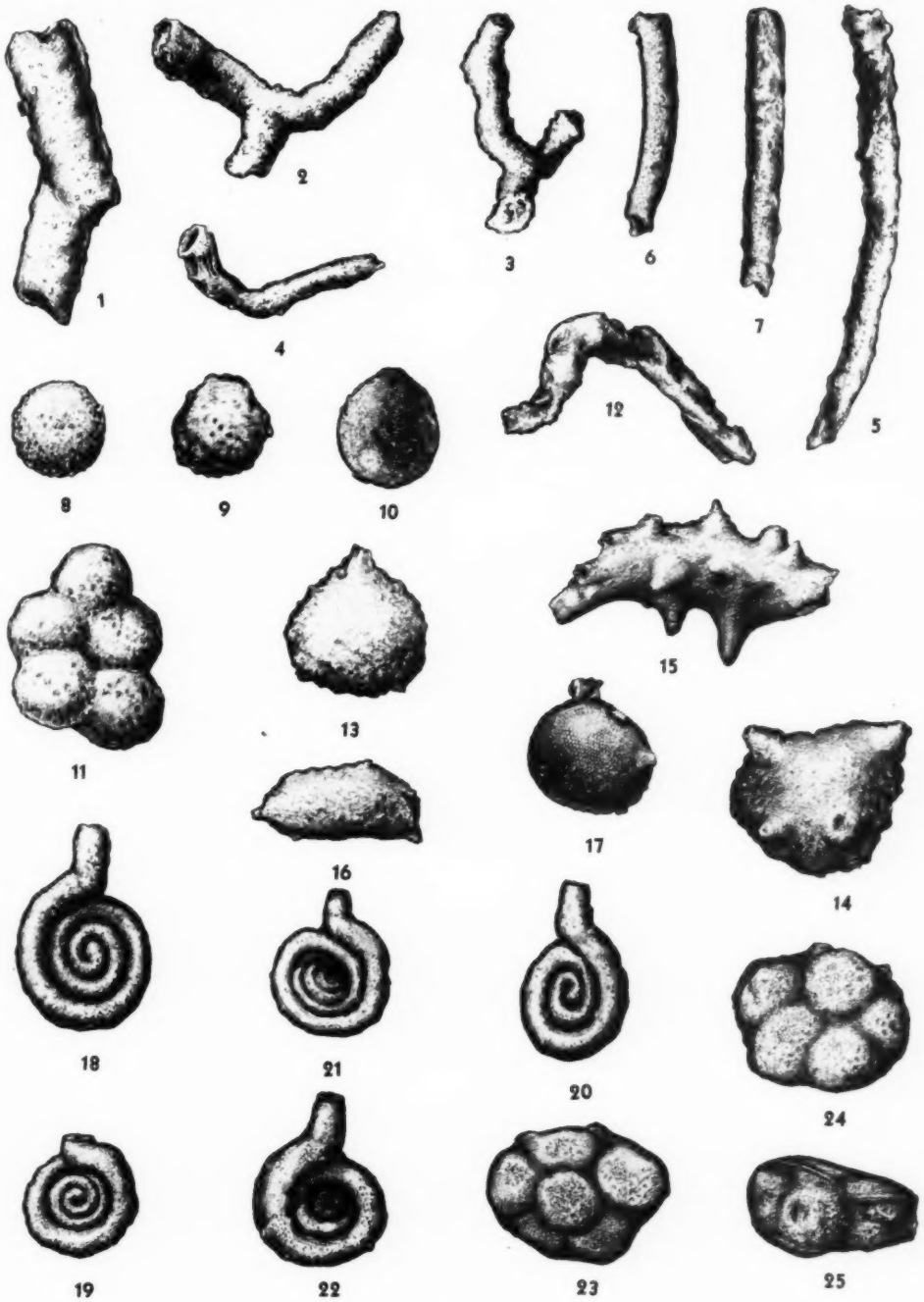
THURAMMINA ARCUATA Moreman
Plate 54, figure 14

Thurammina arcuata MOREMAN, *1930*, Jour. Paleontology, vol. 4, pp. 54–55, pl. 6, figs. 2, 3. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

EXPLANATION OF PLATE 54

(All types deposited in the Geological Museum, Ohio State University.)

FIGS. *1*—*Rhabdammina geniculata*, n. sp. ×57. Holotype no. 18822. (p. 369)
2—*Rhabdammina minuta*, n. sp. ×50. Holotype no. 18823. (p. 369)
3—*Rhabdammina triradiata*, n. sp. ×23. Holotype no. 18824. (p. 369)
4—*Marsipella? torta*, n. sp. ×60. Holotype no. 18825. (p. 370)
5—*Bathysiphon curvus* Moreman ×40. Hypotype no. 18826. (p. 370)
6—*Bathysiphon deminutionis* Moreman ×50. Hypotype no. 18827. (p. 370)
7—*Bathysiphon exiguus* Moreman ×50. Hypotype no. 18828. (p. 370)
8, 9—*Psammosphaera cava* Moreman. *8*, ×40. Hypotype no. 18829; *9*, ×65. Hypotype no. 18830. (p. 371)
10—*Psammosphaera subsphaerica*, n. sp. ×40. Holotype no. 18831. (p. 371)
11—*Sorosphaera osgoodensis*, n. sp. ×40. Holotype no. 18832. (p. 371)
12—*Raibosammina irregularis*, n. sp. ×40. Holotype no. 18833. (p. 372)
13—*Saccammina aspera*, n. sp. ×50. Holotype no. 18834. (p. 372)
14—*Thurammina arcuata* Moreman ×40. Hypotype no. 18835. (p. 372)
15—*Thurammina crescentrica*, n. sp. ×65. Holotype no. 18836. (p. 373)
16—*Thurammina elliptica* Moreman ×60. Hypotype no. 18837. (p. 373)
17—*Thurammina* sp. ×65. Figured specimen no. 18838. (p. 373)
18—*Ammodiscus exsertus* Cushman ×60. Hypotype no. 18839. (p. 373)
19—*Ammodiscus incertus* (d'Orbigny) ×75. Hypotype no. 18840. (p. 374)
20, 21—*Lituotuba exserta* Moreman ×60. Hypotypes (2) no. 18841. (p. 374)
22—*Lituotuba inflata* Ireland ×60. Hypotype no. 18842. (p. 375)
23, 24, 25—*Trochammina? prima*, n. sp. *23*, Dorsal view ×50. Holotype no. 18843; *24*, Ventral view ×50. Holotype no. 18843, *25*, Side view ×50. Holotype no. 18843. (p. 375)



Stewart and Priddy, Niagaran Foraminifera

This species is described by Moreman as follows:

Test free, somewhat inflated, arcuate, triangular, or polygonal in outline; wall thin, composed of fine sand with much cement, surface smooth; apertures at the end of broad to distinct nipples located along the margin of the test at the corners, two, three or four in number; color white.

Only one fragmentary specimen has been found which seems to have the characteristics of this species. The wall is thin and the sand grains composing it are large for the size of the specimen. Four large nipple-like projections are present on the fragment which appears to be about one-half of the original test. Three of the projections occur approximately at the corners along the margin of the test, but the fourth is in the middle of the convex side of the arc.

Diameter of specimen 0.53 mm.

Occurrence.—Zone D, upper limestone of the Osgood formation of Indiana, at locality 5.

Hypotype.—No. 18835, Geological Museum, Ohio State University.

THURAMMINA CRESCENTRICA, n. sp.
Plate 54, figure 15

Test free, of medium size, sub-crescentric in outline; wall thin, consisting of fine, firmly cemented sand grains; surface smooth; apertures at the ends of numerous irregularly arranged, relatively large spine-like projections; color white.

The measurements of the figured specimen are: length 0.63 mm.; diameter 0.18 mm.

The shape and relatively large projections distinguish this form from described species of the genus. In general shape it probably approaches most closely *T. elliptica* Moreman, but the projections are much more numerous and larger.

Occurrence.—Zone F, upper 18 inches of Osgood shaly limestone of Indiana, at locality 5.

Holotype.—No 18836, Geological Museum, Ohio State University.

THURAMMINA ELLIPTICA Moreman
Plate 54, figure 16

Thurammina elliptica MOREMAN, *1930* Jour. Paleontology, vol. 4, p. 54, pl. 5, figs. 2, 4. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Thurammina phasela PRIDDY, *1939*, Jour. Geology, vol. 47, no. 5, p. 496.

This species is described by Moreman as follows:

Test free, ellipsoidal; wall thin, composed of fine sand well cemented; one aperture on each end at the end of a tube-like projection; color white.

The one entire but fragile specimen studied is assigned to this species with some question. The specimen is not so elliptical as *T. elliptica* having one side of the test almost straight. There are three tube-like projections instead of two, the third occurring at the curving side opposite the straight edge. If additional specimens of this form can be found doubtless separation into a new species will be justified.

The dimensions of the specimen are: length 0.35 mm., width 0.16 mm.

Occurrence.—Zone D, shaly middle limestone member of the Osgood formation of Indiana, at locality 1.

Hypotype.—No. 18837, Geological Museum, Ohio State University.

THURAMMINA sp.
Plate 54, figures 4, 17

The one fragmentary specimen of this form which has been found cannot be identified specifically and its position in the genus *Thurammina* is doubtful. The test is spherical, thin-walled, 0.28 mm. in diameter, and made up of minute sand grains with little cement. A curving protuberance which appears to be a continuation of the wall occurs on the broken edge of the shell, and at least two nipple-like extensions can be seen, the open ends of which probably serve as apertures.

The fragmentary condition of the specimen makes it unwise to assign a specific designation at this time.

Occurrence.—Zone B, Osgood formation of Indiana, at locality 5.

Figured specimen.—No. 18838, Geological Museum, Ohio State University.

Family AMMODISCIDAE
Subfamily AMMODISCINAE

AMMODISCUS EXSERTUS Cushman
Plate 54, figure 18

Ammodiscus exsertus CUSHMAN, *1910*, U. S. Nat. Mus. Bull. 71, pt. 1, p. 75 figs. 97a, b

in text; ——, *1921*, U. S. Nat. Mus. Bull. 100, vol. 4, p. 64, pl. 5, fig. 4.

Test free, discoidal, composed of a proloculum followed by a coiled, tubular chamber of three or more volutions coiled regularly about the initial chamber in the same plane; last part of volution becomes uncoiled and extends as a straight tube at right angles from the plane of coiling; aperture at end of tube with diameter slightly less than diameter of tube; test composed of minute sand grains held together by much cement; exterior rough; color of all observed specimens white.

Diameter of coiled portion of figured specimen 0.60 mm. Many specimens are much smaller than this.

The only specific difference between this species and *Lituotuba exserta* is in the manner of coiling of the tubular chamber. There are many specimens which are difficult to separate.

Occurrence.—*Ammodiscus exsertus* is the most abundant of the Foraminifera observed, making up nearly one-half of one percent of the residues from the Dayton limestone at several localities in Ohio and Indiana. It is present in Ohio in the lower four feet of the Dayton limestone at localities 7 and 8, and the upper four feet (zone B) at locality 9; in Indiana it occurs in zone D, shaly middle limestone member of the Osgood formation, at locality 2, zone A, lower limestone member of the Osgood, at locality 3, and zone C, of the Osgood, at locality 5.

This species has been reported by Moreman (1930) from the Chimney Hill limestone (Alexandrian) of Oklahoma, and by Croneis, Dunn and Hunter (1932) from the Bainbridge limestone (Niagaran) of southeastern Missouri.

Hypotype.—No. 18839, Geological Museum, Ohio State University, in the Dayton limestone of Ohio, at locality 7.

Ammodiscus incertus (d'Orbigny)
Plate 54, figure 19

Operculina incerta d'Orbigny in De la Sagra, Hist. Phis. Pol. Nat. Cuba, 1838, "Foraminiferes," p. 49, pl. 6, figs. 16, 17; Spanish Edit., 1840, p. 71, pl. 6, figs. 16, 17.

This species is similar to *A. exsertus* excepting that the second tubular chamber does not become uncoiled in the outer portion. Megalospheric and microspheric forms have not been differentiated. In many specimens it is difficult to determine whether they may not be *A. exsertus* with the straight portion of the tube broken off. The diameter of the test is somewhat variable ranging from 0.35 to 0.45 mm.

Occurrence.—Previously known from the Chimney Hill limestone (Alexandrian) of Oklahoma, and the Bainbridge limestone (Niagaran) of southeastern Missouri, this species is the third most abundant foraminifer found in the residues examined. It occurs in zone A of the Laurel limestone of Indiana at locality 1, zones F and G of the Laurel limestone at locality 5; in the lower Dayton limestone of Ohio (Zone B), at locality 9; and in Indiana in zone A of the Osgood limestone at locality 3, and in zone D at locality 2.

Hypotype.—No. 18840, Geological Museum, Ohio State University, zone F of the Laurel limestone, at locality 5.

Lituotuba exserta Moreman
Plate 54, figures 20, 21

Lituotuba exserta Moreman, *1930*, Jour. Paleontology, vol. 4, p. 59, pl. 7, figs. 5, 6. Chimney Hill limestone (Brassfield, Alexandrian), Oklahoma.

Test free, discoidal, composed of a proloculum followed by a coiled tubular chamber, of three or more volutions coiled about the initial chamber in different planes; the last part of the outer volution becomes uncoiled and extends for some distance as a straight tube practically at right angles to the plane of coiling of the last volution; straight tube decreasing in diameter toward the end, which is open and forms the aperture; cross-section of tubular chamber varies from circular to elliptical; wall composed of minute sand grains of quite uniform size held together by much cement; exterior rough; color of all specimens observed white.

Diameter of coiled portion of average specimen 0.58 mm.

There is a variation in the shape of the test from almost circular to elliptical, the longer axis in the latter being parallel to the direction of elongation of the straight portion of the outer coil. Likewise there is a variation in the outline of the tubular chamber from circular to elliptical.

Occurrence.—This species is quite a common form in zone B of the Dayton limestone

of Ohio, at locality 9; it occurs also in Indiana in zone C of the Osgood formation at locality 2, zone A of the Osgood at locality 3, zone C of the Osgood at locality 5; and in zone G of the Laurel limestone at locality 5. It has previously been recognized in the Chimney Hill limestone (Alexandrian) in Oklahoma (Moreman, 1930), and the Bainbridge limestone (Niagaran) of southeast Missouri (Croneis, Dunn, and Hunter, 1932).

Hypotypes.—No 18841, Geological Museum, Ohio State University, zone C of the Osgood limestone, at locality 2.

LITUOTUBA INFLATA Ireland
Plate 54, figure 22

Lituotuba inflata IRELAND, *1939*, Jour. Paleontology, vol. 13, p. 201, Group B. figs., p. 199, figs. 34, 35. Chimney Hill limestone, Oklahoma.

A few specimens with the outer whorl conspicuously inflated probably should be referred to this species rather than to the more common *L. exserta*. Ireland describes the species as follows:

> Test free, consisting of an ovoid proloculum and a tubular second chamber with three or four coils in various planes, the last whorl uncoiled at right angles to the test and equal in length to about two-thirds of the width of the test, the last coil and the terminal portion well inflated; wall of fine sand well cemented; surface smooth; aperture at the end of the tube, which is slightly constricted; color brown to buff.

All the specimens examined are white in color. The figured specimen has a diameter of 0.29 mm.

Occurrence.—Zone B of Dayton limestone of Ohio, at locality 9.

Hypotype.—No. 18842, Geological Museum, Ohio State University.

Family TROCHAMMINIDAE
Subfamily TROCHAMMININAE
TROCHAMMINA PRIMA Stewart and Priddy, n. sp.
Plate 54, figures 23–25

Test apparently free, sub-trochoid, biconvex, the dorsal side more evenly rounded than the ventral; consisting of an initial globose chamber and five additional chambers more or less irregularly arranged in a volution; all chambers visible on the dorsal surface but on the ventral side only those of the one volution; no apparent depression between chambers; periphery of test marked by a distinct keel; sutures limbate on the dorsal side, of finer shell material than the rest of the test; wall composed of fine sand grains of variable size with much cement; surface smooth; the character and position of the aperture cannot be determined, but it is inferred that it is probably a very narrow slit on the ventral side of the last-formed chamber.

Longest diameter of figured specimen 0.55 mm.

Only one specimen of this species has been recovered from the residues, and it seems to be the first of its kind to be recognized in Silurian strata. It is placed provisionally in the genus *Trochammina*. It has fewer chambers and whorls than is common in the genus and the chambers are less definitely marked off from one another. In the fewer number of chambers it resembles *Globivalvulina bulloides* (Brady) but the chambers do not progressively enlarge as in that species, the lobed aperture is lacking, and the wall is arenaceous instead of calcareous.

If additional specimens of this form can be found, its generic position doubtlessly can be determined with more accuracy.

Occurrence.—Zone D, upper shale member of the Osgood formation of Indiana, at locality 2.

Holotype.—No. 18843, Geological Museum, Ohio State University.

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A DEEP SUBSURFACE PERMIAN FAUNA FROM HOCKLEY COUNTY, TEXAS

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ABSTRACT—Permian fossils from a core taken at 5125 feet in a well in Hockley County, Texas, are described and illustrated. On the basis of these fossils, the strata are tentatively correlated with either the Leonard or Word series.

FOSSILS are rarely recovered from the Permian strata of the subsurface in the middle of the Permian Basin. Few of the numerous well drilling samples have yielded any specimens. Recently a small portion of a core from a well in Hockley County showed abundant and well preserved fossil invertebrates of several phyla. Many of them are identifiable and aid considerably in the correlation of the horizon from which they were secured. By making this fauna known, the authors hope that others may be encouraged to preserve subsurface fossils which may aid in more precise correlation of subsurface zones than is now possible.

The well from which pieces of the core were secured is the Sid W. Richardson Coe no. 1, located 440 feet from the south and west lines of Labor 53, League 40, Maverick County School Lands, Hockley County, Texas. It was drilled by S. W. Richardson, Inc., and to them our thanks are extended for the privilege of studying a portion of the core. The aid of Mr. Marion Funk in securing a piece of the core and in bringing it to our attention is gratefully acknowledged.

A brief partial log of the well follows:

Partial log of Sid Richardson Coe No. 1 well

2010–2170	Red shale
2170–3400	Red shale and anhydrite
3400–3450	Red shale, anhydrite and salt
3450–3750	Red shale and anhydrite
3750–3970	Red shale, anhydrite and brown dolomitic limestone
3970–4030	Red shale and anhydrite
4030–4090	Red shale, anhydrite and brown dolomitic limestone
4090–4910	Red shale, anhydrite and gray dolomitic limestone
4910–4930	Anhydrite and gray dolomitic lime
4930–5182	Tan, gray, drab crystalline dolomitic limestone

Three small pieces of well core were available for study. The first specimen containing fossils was recovered at 5029 feet. The rock is a compact, crystalline dolomitic limestone; it has a few inclusions of calcite and shows some porosity and oil saturation. The piece of core taken at 5055 feet displayed a few indistinct fossils, so poorly preserved as to be unidentifiable. It shows good saturation but little porosity. The most highly fossiliferous piece of core came from a depth of 5152 feet. Lithologically it is a porous brown crystalline dolomite with large areas of calcitic inclusions. Fossils are abundant, and were obtained by breaking the core into small pieces. The fossils are well preserved and occur principally as internal and external molds. Exceptionally some of the molds were filled with calcite.

The fauna is a varied one and comprises corals, bryozoans, brachiopods, pelecypods, gastropods, cephalopods and trilobites. The brachiopods are the most numerous and best preserved and afford more information for purposes of correlation. The fauna is described in detail in the body of the paper.

The following table shows the known ver-

Species	Leonard	Word	Capitan
Punctospirifer billingsi	—	×	—
Hustedia meekana	×	×	×
Composita guadalupensis	×	—	—
Composita mexicana	×	—	—
Dielasma scutulatum	—	—	×
Camerophoria deloi	×	×	×
Pugnoides texanus	×	—	—
Avonia walcottiana	—	×	—
Anisopyga? antiqua	×	—	—
Plagioglypta canna	—	×	—
Orthoceras guadalupense	—	×	—

tical distribution of the species we were able to identify in the cores.

In summary, six of the species occur in the Leonard, four of them exclusively so. Six occur in the Word, three exclusively. Three occur in the Capitan, one exclusively, the other two also occurring in the Leonard and Word. From these occurrences we may conclude that the fossiliferous core at the depth of 5125 feet in the Richardson Coe no. 1, may be from strata equivalent to either the Word or Leonard. Probably low in the Word or high in the Leonard is as near as we would be warranted in dating the strata from the evidence at hand. Further collections from the same horizon, as drilling continues, may substantiate or disprove our present conclusion as to the age of the fauna.

SYSTEMATIC DESCRIPTIONS

Phylum COELENTERATA

Class ANTHOZOA

LINDSTROEMIA sp.

A portion of an external mold of a small coral is the only evidence of this group of animals recovered from the core. It is 7.6 mm. long, 3 mm. in diameter at the larger end and shows the imprints of interseptal ridges. Specific identification is not possible at this time.

Depth.—From core at depth of 5125 feet.

Type.—The specimen is M.A.S. no. 1240, in the Stainbrook collection.

Phylum BRYOZOA

Several bryozoans are represented in our material. Since they are in the form of molds they are not easy to identify with certainty. Some of them, however, permit comparison with species illustrated by Girty. One, a fenestelloid, resembles *Fenestella hilli* Girty. Another is near the form questionably identified by Girty as *Polypora mexicana* Prout? The third is a slender branching form with a stem less than a millimeter in diameter.

Depth.—From core taken at the depth of 5125 feet.

Types.—The specimens are in the collection of M. A. Stainbrook.

Phylum BRACHIOPODA Cuvier

Order PROTREMATA Beecher

Family PRODUCTIDAE Gray

Genus AVONIA Thomas

AVONIA WALCOTTIANA (Girty)

Plate 55, figure 18

Productus walcottiana GIRTY (pars), *1908*, U. S. Geol. Survey Prof. Paper 58, pp. 269–270, pl. 21, figs. 27–27b.

Avonia walcottiana KING, *1930*, Texas Univ. Bull., no. 3042, p. 85, pl. 21, figs. 1–5.

Two nearly complete internal molds of pedicle valves and various portions of internal molds and casts constitute the material recovered from the core for study.

The best preserved hypotype, the internal mold of a pedicle valve, measures 13.1 mm. in length, 15 mm. in width and 7.5 mm. in depth. It is subquadrate in outline with rounded anterolateral margins, wider than long, strongly convex, and highest near the midpoint whence the surface descends abruptly to the hingeline and the anterior margin; transversely, the surface curves gently a short way and then abruptly to the lateral margins; anterior median portion flexed by a scarcely perceptible sinus; angles nearly right angled and slightly auriculate. Anterior half of the valve plicate; the plications are simple, low, variable in width, usually narrow, as wide as or narrower than the interspaces. Posterior portion of the valve marked by moderately strong concentric growth wrinkles and several plications of which none reaches the beak. External molds indicate the spines were scattered, few in number, larger toward the front and merging there with the costae.

Our specimens are referred to *Avonia walcottinana* with considerable hesitancy. They resemble that form in several respects. They are similar in shape and in the proportion of the dimensions, are wider than long, costate anteriorly, concentrically wrinkled posteriorly and toward the front have spines merging with the costae. They differ from typical *Avonia walcottiana* in having the greatest convexity near the midpoint and more continuous costae on the front of the valves. In this respect our form is more like King's variety *costata*, but differs otherwise in being short, in having the width greater than the length and in being less convex.

Depth.—From core at depth of 5029 feet.

Types.—The hypotypes are M.A.S. 1241, in the Stainbrook collection.

Order TELOTREMATA Beecher
Family CAMAROTOECHIIDAE
Schuchert and Levene
Genus PUGNOIDES Weller
PUGNOIDES TEXANUS (Shumard)
Plate 55, figures 6–9

Rhynchonella texana SHUMARD, *1859*, St. Louis Acad. Sci. Trans., vol. 1, p. 393.
Pugnoides texanus KING, *1930*, Texas Univ. Bull., no. 3042, p. 108, pl. 34, figs. 5–9.

Shell small, subequally biconvex, subtriangular in outline with acute posterior and rounded anterolateral margins, longer than wide, broadest posterior to the midlength. A complete hypotype measures 10.3 mm. in length, 8.9 mm. in width and 6.6 mm. in thickness. An incomplete specimen with a portion of a lateral margin missing is 9.8 mm. long, 6.1 mm. thick and was apparently about 9.8 mm. wide.

Pedicle valve depressed convex, gently arched from beak to front and slightly flattened at the midpoint, gently arched transversely. Sinus originating at the midpoint, shallow, scarcely defined at the sides, continued at the front to form a short, upwardly turned lingual extension. Umbo high, narrow; beak long, pointed, and but little incurving, pierced by a small foramen. Interior of the beak displays two short laterally curved septa.

Brachial valve a little more convex than the pedicle, highest anterior to the midlength, regularly arched from beak to front, more strongly so transversely, slightly flattened at the midpoint. Fold short, but little elevated and not well defined. Umbo narrow not much elevated; beak small, pointed. A short median septum appears internally in the beak.

Plications short, present only on the anterior halves of the valves; three are present on the fold, two in the sinus and about five on each lateral slope; those on the slopes decrease progressively in size posteriorly.

Our species is near that illustrated by Girty as *Pugnax osagensis* but differs from those illustrated by King in that ours are longer than wide and more triangular in shape and have the greatest width anterior to the midlength. In the proportions of the shell our specimens agree closely with the dimensions given by King for Shumard's type specimen which is also longer than wide. One of our specimens is nearly as broad as long but is broadest anteriorly. The postero-lateral angles of our specimens form an angle at the beak of 66°; these are also very close to that of Shumard's type.

Depth.—From core at depth of 5125 feet.

Types.—The hypotypes are M.A.S. 1244, in the Stainbrook collection.

CAMEROPHORIIDAE
Genus CAMEROPHORIA King
CAMEROPHORIA DELOI King
Plate 55, figures 15–27

Camarophoria deloi KING, *1930*, Texas Univ. Bull., no. 3042, p. 110, pl. 34, figs. 24–37.

The material at hand is a nearly complete internal mold of a shell of which the posterior portion is missing, and a portion of the external mold.

Shell small, subequally biconvex, subtriangular in outline with rounded anterolateral margins and truncate front margin. It measures 10.9 mm. in width, 8.1 mm. in thickness and apparently was about 10 mm. long.

Pedicle valve depressed convex, gently arched transversely, strongly curved from beak to front. Sinus broad, shallow, originating in front of the midpoint, sharply defined at the sides, continued at the front as a broad, short lingual extension.

Brachial valve more convex than the opposite valve, about equally arched from beak to front and from side to side. Fold broad, low, flat, defined at each side by a slightly larger plication, and extending from the front margin posteriorly to the midpoint. Umbonal region depressed, smooth.

Plications short, confined to the anterior portions of the valves, narrow, rounded, separated by narrower interspaces, numbering five on the fold, four in the sinus and about seven on each slope where they progressively decrease in size toward the beak.

Externally the specimen appears to be a *Pugnoides*. The beaks of both valves are broken away and internal characters are obscured. There appears, however, to be evidence of a sessile spondylium in the pedicle valve and of a cruralium in the brachial. Our example has one more plication on each slope that those of King. Also the plications of

our example do not extend as far posteriorly, but this condition may be because our specimen is an internal mold.

Depth.—Core at depth of 5125 feet.

Types.—Hypotypes are M.A.S. 1425, Stainbrook collection.

Family DIELASMATIDAE Schuchert

Genus DIELASMA King

DIELASMA SCUTULATUM Girty
Plate 55, figure 28

Dielasma? scutulatum GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, pp. 332–333, pl. 16, figs. 8–9b.

Shell small, subovate in outline, pointed posteriorly, widest near the midlength and with broadly rounded lateral margins. The single hypotype, an internal mold with a portion of the anterolateral margin missing, measures 10 mm. in length, 9.1 mm. in width and 6.3 mm. in thickness.

Pedicle valve moderately convex, highest in the umbonal region whence the surface slopes with even gentle curvature to the front and lateral margins, strongly arched over the umbo along the midline, gently arched from side to side anteriorly and more strongly so posteriorly. Umbo high, narrow, extended beyond the hingeline; beak small, pointed, incurving. Two short septa occur in the internal mold of the beak.

Brachial valve not as convex as the pedicle, highest a little posterior to the midpoint, elevated slightly along the midline. Umbo a little elevated; beak small and a little projecting. Internally there are two, short, laterally curved septa.

Our specimen differs from that described by Girty in having the brachial valve less convex than the pedicle. Otherwise they are quite the same judging only from Girty's description and illustration.

Depth.—From well core at depth of 5125 feet.

Type.—Hypotype M.A.S. 1239, Stainbrook collection.

Family SPIRIFERINIDAE Davidson

Genus PUNCTOSPIRIFER North

PUNCTOSPIRIFER BILLINGSI (Shumard)
Plate 55, figures 1–5

Spiriferina billingsi SHUMARD, *1858*, St. Louis Acad. Sci. Trans., vol. 1, p. 294; GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, pp. 374–376, pl. 13, figs. 16–19d, 21–21b, 24–24c; pl. 14, figs. 15–16.

Punctospirifer billingsi KING, *1930*, Texas Univ. Bull., no. 3042, pp. 124–125, pl. 42, figs. 15–18.

Two complete internal molds, a portion of the external mold of a pedicle valve and portions of the internal molds of disconnected valves are available for study.

Shell below medium size, biconvex, wider than long with the greatest width between the hingeline and the midlength, subpentagonal in outline with broadly rounded anterolateral margins. Measurements of the best preserved hypotypes are: length 12.2 mm.; width 13.3 mm.; thickness 9.2 mm.

Pedicle valve more convex than the brachial, strongly and regularly arched from beak to front, highest in the umbonal region, the surface sloping rather abruptly to the lateral margins. Sinus deep, narrow, rounded at the bottom, extending from beak to front and forming there a short lingual extension. Lateral slopes curving gently from the borders of the sinus to the angles and strongly arched from back to front. Umbo strongly developed, extended posteriorly; beak pointed and incurving. Area high, flat near the hingeline, strongly curved beneath the beak, the lower portion being at right angles to the plane of the valve. In the beak is a linear depression indicative of a strong median septum which extended from the beak to the midpoint, and which was apparently higher near its mid-length. A shorter, slightly thinner septum is indicated on each side of the preceding by a deep narrow groove.

Brachial valve semielliptical in outline with the front margin short and slightly emarginate, regularly arched from beak to front and from side to side, highest at the midpoint. Fold high, narrow, moderately elevated, flattened a little along the summit, truncated at the front. Umbo small, beak slightly projecting. Internally a shallow linear depression is indicative of a median septum.

Plications simple, strong, narrow, subangular along their summits, extending to the beaks, numbering from five to six on each slope. On the external mold of the pedicle valve, a narrow mesial costa appears in the bottom of the sinus; it does not appear on

the internal mold. The external mold shows that the surface had numerous concentric lamellose growth lines, several of which are more prominent; two of them being impressed on the internal mold. Surface of the external mold shows numerous granular elevations indicating that the surface of the shell was punctate.

Generically the form is near *Spiriferina* and *Punctospirifer*, but is more like the latter genus in that the fold and sinus are notably larger than the plications and numerous growth lamellae are present. It agrees with *Punctospirifer billingsi* in most particulars but differs in having a slight median costa in the sinus. In this respect and others, it is similar to *Spiriferina hilli* Girty but differs from that species, according to King's diagnosis in not having the plication on each side of the sinus considerably larger. It also differs in that the length and width are more nearly equal and in that the greatest width is more anterior. If Girty's illustration of the type specimen of *Spiriferina hilli* is representative, our specimens are easily separable from it.

Depth.—From core at depth of 5125 feet.

Types.—Hypotypes are M.A.S. 1229, Stainbrook collection.

Family RHYNCHOSPIRINIDAE Schuchert and Levene

Genus HUSTEDIA Hall and Clarke

HUSTEDIA MEEKANA (Shumard)

Plate 55, figures 10–14

Retzia meekana SHUMARD, *1859*, St. Louis Acad. Sci. Trans., vol. 1 p. 395, pl. 11, figs. 7 a–b.

Hustedia meekana GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, pp. 394–396, pl. 14, figs. 22–24; KING, *1930*, Texas Univ. Bull., no. 3042, pp. 126–127, pl. 42. figs. 34–39.

The material for study consists of one nearly complete internal mold and several internal molds of separate valves. The nearly complete specimen measures 10.1 mm. in length (incomplete), 8.7 mm. in width, and 6.5 mm. in thickness. Another hypotype, an internal mold of a brachial valve, is 12.5 mm. long and 10.6 mm. wide.

Shell is biconvex, ovate in outline, acute posteriorly, rounded anteriorly, wider than long with the greatest width anterior to the midlength. Pedicle valve strongly arched from beak to front, more strongly so transversely, highest near the midpoint. Umbo high and narrow; beak strong, pointed and incurving.

Brachial valve shorter than the pedicle, but as convex; highest in the umbonal region, the surface curving thence with equal rapidity to the front and lateral margins, incurved beneath the beak. The imprint of a short, narrow median septum appears in the beak.

The internal molds of the valves are marked by from 10 to 12 strong, simple, narrow, rounded radial plications which extend from the beak to the front and lateral margins. The interspaces are as wide or wider, flat at the bottom, and usually have a slight linear depression on each side

EXPLANATION OF PLATE 55

FIGS. *1–5—Punctospirifer billingsi* (Shumard). *1–3*, Pedicle, brachial and anterior views, ×2, of an internal mold; *4*, Posterior view of another internal mold; *5*, View of a squeeze showing character of the exterior of a pedicle valve. (p. 379)

6–9—Pugnoides texanus (Shumard). *6*, Lateral view, ×2, of an internal mold; *7–9*, Anterior, pedicle and brachial views, ×2, of a complete internal mold. (p. 378)

10–14—Hustedia meekana (Shumard). *10–12*, Pedicle, brachial and lateral views, ×2, of an internal mold. *13*, Lateral view, ×2, of a crushed internal mold; *14*, View, ×2, of the internal mold of a brachial valve. (p. 380)

15–17—Camerophoria deloi King. Pedicle, brachial and anterior views, ×2, of a nearly complete internal mold. (p. 378)

18—Avonia walcottiana (Girty). View, ×2, of the internal mold of a pedicle valve. (p. 377)

19–21—Composita guadalupensis Girty. Pedicle, brachial and anterior views, ×2, of an internal mold. (p. 381)

22—Pleurophorus sp. Lateral view, ×2 of an internal mold. (p. 382)

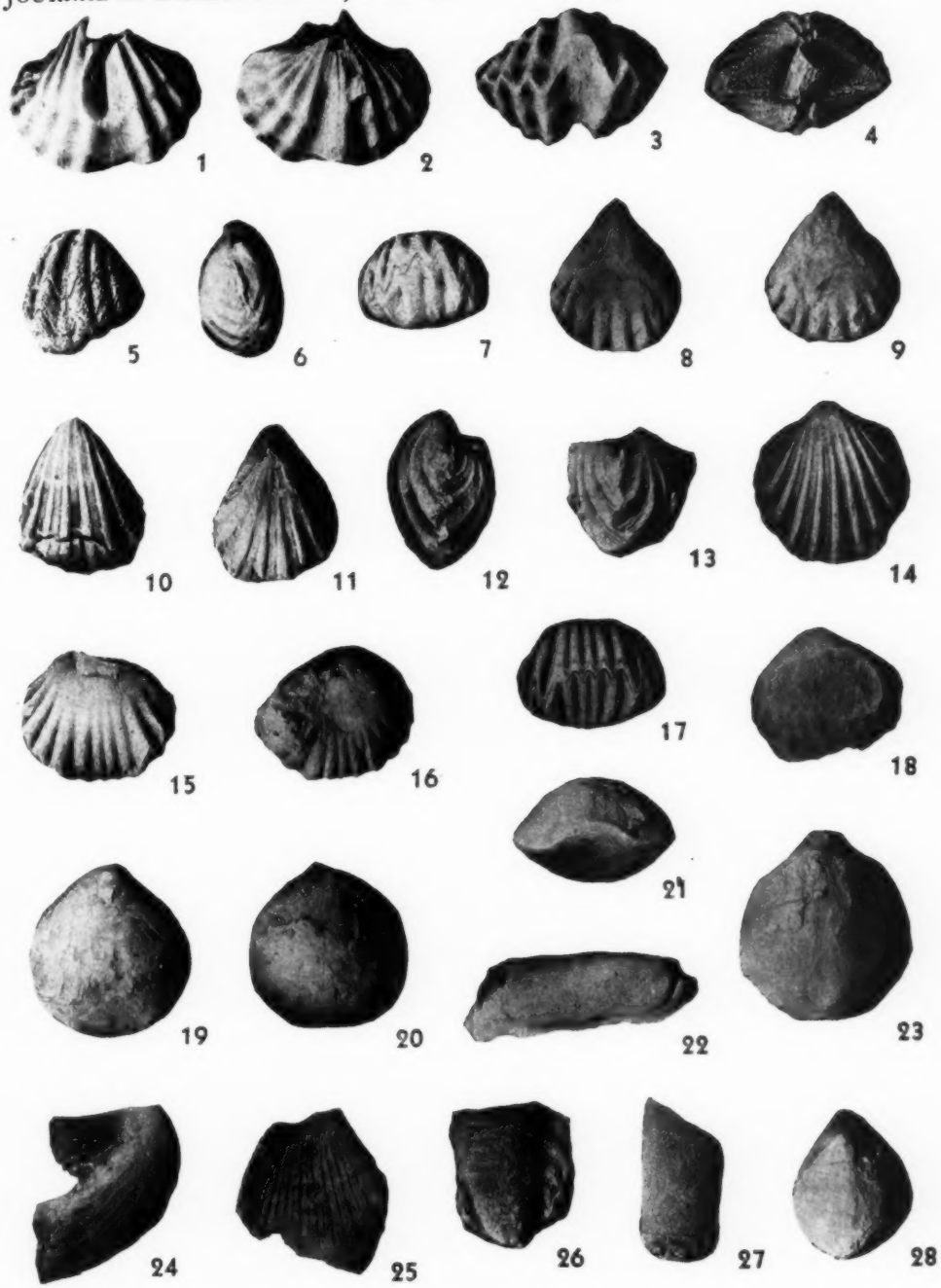
23—Composita mexicana (Hall). Brachial view, ×2, of an internal mold. (p. 381)

24–25—Aviculopecten sp. *24*, View, ×2, of an incomplete internal mold. *25*, View, ×2, of another incomplete internal mold. (p. 382)

26—Anisopyge? antiqua Girty. View, ×2, of the incomplete internal mold of a pygidium. (p. 383)

27—Orthoceras guadalupense Girty. Lateral view, ×2, of an incomplete internal mold. (p. 382)

28—Dielasma scutulatum Girty. Brachial view, ×2, of an internal mold. (p. 379)



Stainbrook and Madera, Permian Fossils

adjacent to the plication. Anteriorly on the sides of the plications there are several small costae in some specimens.

Our specimens in nearly every particular agree well with Girty's description. Since our specimens are internal molds only, they do not show the features of the exterior. On a crushed incomplete specimen costae are well developed on the sides of the plications, a characteristic feature of *Hustedia meekana*.

Depth.—From a core taken at a depth of 5125 feet.

Types.—The hypotypes are M.A.S. 1238, Stainbrook collection.

Family ATHYRIDAE Phillips

Genus COMPOSITA Brown

COMPOSITA GUADALUPENSIS Girty

Plate 55, figures 19–21

Composita mexicana var. *guadalupensis* GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, p. 390, pl. 24, figs. 11–13b.

Our examples are both internal molds; one is nearly complete except for the pedicle beak and the other has the valves twisted and broken. Shell small, subovate in outline with broadly rounded anterolateral and posterolateral margins, slightly truncate anteriorly and widest at the midlength. Dimensions of a hypotype are: length 11.5 mm.; width 11.1 mm.; thickness 7.3 mm.

Pedicle valve strongly and regularly arched from beak to front less strongly so transversely, highest in the umbonal region whence the surface curves gently to the lateral margins and strongly to the hinge-line. Umbo high and narrow. Sinus short, shallow, confined to the anterior medial third of the valve, merging gradually with the lateral slopes. Internally two short septa appear in the beak.

Brachial valve about as convex as the pedicle, subcircular in outline, arching with increasing rapidity from the beak to the front, moderately and regularly arched transversely, highest a little posterior to the midlength, slightly flexed mesially by a very short, broadly convex fold which is confined to the anterior portion of the valve.

King has included *Composita mexicana* var. *guadalupensis* in *Composita mexicana* Hall, but it has seemed more logical to consider *Composita guadalupensis* as distinct. A comparison of the illustration of Girty's type (plate 24, figs. 11a–c), shows it to differ from Hall's illustration in each view. Our specimen agrees in every particular with the illustration of Girty in the size, shape and appearance. On the other hand, our example is not as long as *Composita mexicana*, and it is more ovate in shape, less triangular. It has a shorter and less distinct fold and lacks the distinct, short mesial sulcus of that form.

Depth.—From core at 5125 feet.

Types.—Hypotypes M.A.S. 1230, Stainbrook collection.

COMPOSITA MEXICANA (Hall)

Plate 55, figure 23

Terebratula mexicana HALL, *1857*, Emory's Report U. S. and Mexican Boundary Survey, vol. 1, pl. 20, fig. 2.

Composita mexicana GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, pp. 389–390; GIRTY, *1909*, U. S. Geol. Survey Bull. 389, p. 68, pl. 8, fig. 1; KING, *1930*, Texas Univ. Bull., no. 3042, pp. 128–129, pl. 43, figs. 1–11.

One specimen, a nearly complete internal mold, is referable to this species. The shell is below medium size, subovate in outline, broadest anterior to the midlength, subequally biconvex and strongly sinuous along the anterior commissure. Our example measures 12.7 mm. in length (incomplete), 11.6 mm. in width and 8.1 mm. in thickness.

Pedicle valve most convex in the umbonal region, strongly arched transversely, depressed anteriorly by a median sinus which originates in front of the midlength and continues forward to form a short lingual extension nearly perpendicular to the plane of the valve.

Brachial valve arching with decreasing curvature toward the front, more strongly arched transversely, elevated along the median line, depressed anteriorly on each side of the short medial fold.

Composita mexicana is proportionately longer than *Composita guadalupensis*, is more oblong and less circular in shape. The specimen has a stronger fold and sinus and consequently a more sinuous anterior commissure.

Depth.—From core at depth of 5125 feet.

Type.—Hypotype, is M.A.S. 1231, Stainbrook collection.

Phylum Mollusca
Class Pelecypoda

The pelecypoda are better represented than the other classes of mollusks. Most of the examples are incomplete molds and do not admit of certain identification. One resembles *Astartella nasuta* Girty. Another, incomplete, seems to be a coarsely and concentrically wrinkled *Astartella*. A third, minute and an internal mold, is modioloid. Two others are not identifiable. Two forms are referred to *Aviculopecten* and *Pleurophorus* without specific designation.

Aviculopecten sp.
Plate 55, figures 24–25

The material for study consists of several incomplete internal and external molds. One of them a portion of a left valve shows the anterior wing and the umbo.

The species in size and shape is near *Aviculopecten guadalupensis* Girty. The main difference is in the nature of the radial costae. These are more than 40 in number, small, fine, in three sets based on size; they increase by intercalation. Between each two of the largest costae is a medium sized one with a smaller one on each side. The largest costae especially increase in height and thickness a little, near the ventral margin. On the anterior wing of the left valve are about eight costae, all about the same size. In other specimens which cannot be determined as right or left valves, the arrangement of the costae noted above holds true.

Our specimens are fragmentary but the external sculpture separates them readily from *Aviculopecten guadalupensis* which has split costae in the right valves. All of our specimens may be left valves, but they differ also from the left valve of A. *guadalupensis* as illustrated by Girty. Our form is apparently unlike any other of the forms of the genus described by Girty.

Depth.—From well core at depth of 5125 feet.

Types.—Specimens are M.A.S. 1237 and 1247, Stainbrook collection.

Pleurophorus sp.
Plate 55, figure 22

The specimen at hand is the nearly complete internal mold of a right valve of which a portion of the posterior is missing.

Shell small, elongate, probably three times as long as high when complete, subrectangular in outline with rounded angles, subparallel dorsal and ventral margins and beak anterior in position. Valve moderately arched, more strongly so toward the dorsal margin. A poorly defined ridge extending from the umbo to the posteroventral margin, becomes more apparent posteriorly and merges there with the area above and below. Along the ventral margin is an indentation indicative of the thick edge of the valve beyond the pallial line. Extending from the beak to the ventral margin and directed slightly posteriorly is a deep groove indicating a strong umbonal septum. Immediately in front is the mold of a deep adductor scar. The mold of the posterior adductor scar is larger, longer and a little lower in position. A squeeze of the hinge region indicates that there may have been one (possibly two), small hinge teeth. Exterior unknown.

Depth.—From well core at depth of 5125 feet.

Type.—Specimen is M.A.S. 1323, Stainbrook collection.

Class Gastropoda

Gastropoda are represented by an incomplete internal mold of two whorls. The form is similar to some species of *Pleurotomaria* described by Girty.

Class Scaphopoda
Plagiogypta canna (White)?

Plagiogypta canna (White) *in* Girty, *1908*, U. S. Geol. Survey Prof. Paper 58, p. 450, pl. 23, figs. 11–13.

Several incomplete internal and external molds of a scaphopod are present in our material. They indicate a form, straight, gently tapering, smooth, and several millimeters in diameter at the larger end. They appear to be similar to the specimens illustrated by Girty, but the nature of their preservation does not permit certain identification.

Depth.—From core at depth of 5125 feet.

Types.—The hypotypes are M.A.S. 1246, Stainbrook collection.

Class Cephalopoda
Orthoceras guadalupense Girty
Plate 55, figure 27

Orthoceras guadalupense Girty, *1908*, U. S. Geol. Survey Prof. Paper 58, p. 497, pl. 23, figs. 10–10b.

A portion of the internal mold of a cephalopod displaying a part of the body chamber and the chamber posterior to it, and a section of a smaller specimen are the materials recovered. The larger fragment indicates a specimen a centimeter or so in diameter, smooth, with a posterior chamber 2.5 mm. in thickness. The second is a smooth specimen, 3.8 mm. in diameter showing a single septum.

Depth.—From well core at depth of 5125 feet.

Types.—Hypotype, M.A.S. 1233, Stainbrook collection.

Phylum ARTHROPODA

Class CRUSTACEA

Subclass TRILOBITA

ANISOPYGE? ANTIQUA Girty

Plate 55, figure 26

Anisopyge? antiqua GIRTY, *1908*, U. S. Geol. Survey Prof. Paper 58, p. 509, pl. 24, figs. 23–26.

Pieces of trilobites are not uncommon in the rock core but are difficult to secure in complete form. Specimens at hand, internal and external molds, are all more or less broken and consist of pygidia, a free cheek and portions of glabellae. All pieces are small and the pygidia alone yield diagnostic details.

The pygidium is wider than long and has the axial lobe considerably elevated. The number of axial segments cannot be ascertained from the material, but they are shorter, more closely approximated and smaller than those on corresponding portions on the pleural lobes. They also do not extend across the full width of the lobe. The axial lobe has a narrow band, unmarked by axial furrows, around it adjacent to the furrow separating the axial lobe from the pleural lobes. The end of the axial lobe approaches closely to the rear border of the pygidium.

Remarks.—The nearness of the axial lobe to the posterior border of the pygidium, the band about the axial lobe, and the differences in size and width between the segments of the axial lobe and the pleural lobes are features distinctive of *Anisopyge? antiqua* Girty.

Depth.—From core at depth of 5125 feet.

Types.—The hypotypes are M.A.S. 1236, Stainbrook collection.

MANUSCRIPT RECEIVED BY THE EDITOR JANUARY 8, 1940.

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NEW CRINOID FAUNA FROM THE PITKIN LIMESTONE[1] OF NORTHEASTERN OKLAHOMA

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ABSTRACT—Excellently preserved fossil crinoids have been collected at many localities throughout northeastern Oklahoma from a dense lithographic limestone member that lies near the middle of the Pitkin limestone. The present collection contains 11 species distributed among six genera. Fragmentary material contains remains of a considerable number of other species whose diagnostic characters cannot be completely determined. One new genus, *Carcinocrinus*, is described. *C. stevensi*, n. sp., is designated as the genotype.

The fauna contains two species of *Pelecocrinus* of which one, *P. stereosoma*, is new; one new species *Linocrinus floweri;* five species of *Scytalocrinus*, of which three, *S. dunlapi*, *S. braggsi*, and *S. garfield*, are new; one new genus and species *Carcinocrinus stepevensi;* and one species of *Catillocrinus*.

FOSSIL CRINOIDS occur in profusion in the Kinderhook and Osage subseries in the upper Mississippi valley. For some reason at the end of Osage time large numbers of these genera and species became extinct. Recently, considerable numbers of species of rather unusual crinoids have been described from the Morrow formation of Oklahoma and Arkansas by Moore and Plummer (1937). Fossil crinoids are being discovered in increasing numbers in the upper Carboniferous formations. Forms recently described from the Pennsylvanian strata of Kansas and Oklahoma by Moore (1939) differ greatly from the crinoids of the early Mississippian. Consequently the discovery of well preserved crinoid remains in the Chester formations offers valuable connecting links in the chain of evolution between the late Osage species and the forms of the early Pennsylvanian formations.

The Pitkin limestone was named by Girty and Adams (Adams 1904) with the type section designated near Pitkin in Washington county, Arkansas. The formation is extensively exposed in northeastern Oklahoma and northern Arkansas. It is unconformably overlain by beds of Morrow age and conformably underlain by the Fayetteville shale. Thus it can be seen to lie at the top of the Chester subseries as exposed in this area.

In northeastern Oklahoma, the Pitkin limestone consists of several lithologic members that are rather persistent throughout the area of exposure of the formation. The crinoids described in this paper, with one exception, come from a dense, dark, semi-lithographic limestone member that normally occurs near the middle of the formation. The crinoid-bearing strata are easily recognized in that they weather to rounded nodular masses; the weathered surfaces are always of a very light bluish gray color. Crinoids have been collected in this member throughout the entire area of exposure in northeastern Oklahoma.

Because of the density of the stone, the task of preparing specimens for study is extremely difficult. Most of the specimens used in this paper have been weathered naturally from the limestone. We have in our collections a large number of specimens showing complete stems, arms, and calyces that are too deeply buried in the dense limestone to be available for study. Some of them undoubtedly represent new species.

The crinoid fauna of the Pitkin limestone exhibits typical upper Carboniferous tendencies in that it consists entirely of inadunate crinoids. The great camerate crinoid fauna of the Kinderhook and Osage subseries is entirely missing. The fauna, with one exception, belongs with the Poteriocrinitidae (Moore, 1937, p. 236). Survivors from the Kinderhook and Osage subseries

[1] This paper was completed and submitted for publication some months before the terminology discussed by Moore and Laudon on p. 412 was compiled, therefore the revised terminology for describing crinoids has not been incorporated into this contribution.

are represented with *Pelecocrinus*, *Linocrinus*, *Scytalocrinus*, and *Catillocrinus*. The unusual development of species within the genus *Scytalocrinus* and its related genus *Phanocrinus* (Kirk, 1937) seems to be most characteristic of the Chester subseries. The new genus *Carcinocrinus* is a progressive form derived from *Culmicrinus* which is so characteristic of the Meramac subseries. The genus *Catillocrinus* is now known to survive until Morrow time.

By far the greater number of the crinoids used in this report were collected by students at Tulsa University. I should like to acknowledge particularly the work of the following people: Arthur Bowsher, Robert Stevens, George Dunlap, Jane Eckle, John L. Gartner, and Paul Aldridge. Each of these individuals collected one or more of the specimens figured in this paper.

SYSTEMATIC DESCRIPTIONS

Order INADUNATA Wachsmuth and Springer
Family PELECOCRINIDAE Kirk
Genus PELECOCRINUS Kirk

With the erection of the genera *Cosmetocrinus* and *Pelecocrinus* by Kirk (1941) the confusion centered around the genus *Pachylocrinus* has been partially clarified. When *Pachylocrinus* was first defined by Wachsmuth and Springer (1879, pt. I, p. 115), no specimens were figured. The original generic description included forms that were quite different from many commonly referred to *Pachylocrinus* today. The original description states

> Calyx depressed, underbasals forming a concavity, and not extending beyond it.

P. aequalis from the Keokuk beds was designated as the type. In the same report, however, forms having a steeply conical calyx were also designated as examples of the genus. Forms having the steeply conical calyx have since been found to occur much more commonly than those with the bowl shaped calyx. Hence the confusion has grown.

Moore[2] has suggested that the genus *Pachylocrinus* be limited to forms having a bowl-shaped calyx with the IBB definitely not showing on the lateral wall.

When the manuscript for this paper was first completed, a new genus was erected and *Pelecocrinus stereosoma*, n. sp., was included in it. With the publication of the recent paper by Kirk (1941) *P. stereosoma*, n. sp., was found to be an excellent example of *Pelecocrinus* and so this manuscript has been revised.

Cosmetocrinus and *Pelecocrinus* are both definite types that heretofore have been erroneously referred to *Pachylocrinus*. In order to further clarify the genus *Pachylocrinus*, the writer suggests expansion of the genus *Cosmetocrinus* to include such forms as *Pachylocrinus spartarius* (Laudon and Beane, 1937), in which the calyx is steeply conical, the IBB form a conspicuous portion of the lateral calyx wall, and commonly two, instead of one, IBr in each arm. If *Cosmetocrinus* is not expanded to receive these forms another new genus certainly should be erected to care for them.

PELECOCRINUS STEREOSOMA Laudon, n. sp.
Plate 56, figures 1, 2

A large heavy, robust form of *Pelecocrinus*. Holotype: height of calyx, 21 mm., width at arm bases, 37 mm. Arms broken, longest portion 49 mm., probably at least 75 mm. in length when complete.

IBB 5, large, forming a definite part of the calyx wall. A definite concavity developed in lower portion of IBB for first columnals. Height of IBB on lateral wall 3.5 mm. Width at widest point 7 mm. BB 5, large, hexagonal except pB which is heptagonal, average height 11 mm., greatest width 13 mm. RR 5, height 9 mm., width 16 mm. RR facets straight, considerably less than greatest width of plate. RA in normal position resting on pB and rpB, in contact with x and rpR laterally, and supporting rt. RA height 9 mm., width 7 mm. x in normal position, equal in size to RA, resting on tuncated pB, in contact laterally with lpB, rt, and RA, supporting lt. Plate surfaces without ornamentation.

Sac structure unknown.

Arms thick, robust, uniserial with occasional irregular development of biserial structure, tapering rather rapidly, probably averaging a little more than 3.5 times height of calyx. Isotomous with irregularities tending toward endotomous structure. IBr slightly less in width than RR, axillary,

[2] Moore, R. C., 1940, personal communication.

average height 5 mm., width 13 mm. IIAx considerably larger than IIBr. IAx width 13 mm., IIAx width 9 mm., IIIAx width 5.5 mm., IVax width 4 mm. lp ray endotomous above IIAx. rp ray apparently isotomous throughout. Pinnules coarse, relatively short.

This species of *Pelecocrinus* represents one of the highly specialized forms of the genus. It may be distinguished from other species by its large size, general robust nature, broadly flaring calyx, and slightly irregular arm structure.

Occurrence.—Pitkin limestone, ½ mile southeast of Hulbert, Oklahoma in the road cut on the face of the faultline scarp, SE ¼, sec. 27, T. 17 N., R. 20 E., Muskogee Quadrangle.

Types.—University of Tulsa, Holotype J-500. Paratype J-501.

Genus COSMETOCRINUS Kirk

COSMETOCRINUS sp.

Plate 56, figure 3

This small form is tentatively referred to *Cosmetocrinus* although it probably does not belong with the genus as defined by Kirk (1941). It is represented by a single specimen in which the calyx structure is so badly broken and weathered that specific determination is not possible. It is figured here for whatever stratigraphic value it may have. Its delicate arm structure suggests comparison with the more primitive forms that heretofore have been referred to *Pachylocrinus*.

Occurrence.—Pitkin limestone, 1½ miles southeast of Garfield in the NE. ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Figured Specimen.—University of Tulsa, J-502.

Genus LINOCRINUS Kirk

LINOCRINUS FLOWERI Laudon, n. sp.

Plate 56, figure 4

This species is apparently the largest form of the genus *Linocrinus* that has been recognized in the North American Carboniferous as yet. It answers to all of the characteristics of the genus as defined by Kirk (1938, p. 168).

Crown expanding, fairly rapidly, then sharply incurving at top. Width of calyx at RR tops 16 mm., height 3.5 mm. Arms approximately 34 mm. in length. Calyx plates rugose, arm brachials with an angular median ridge giving a general angular appearance to the species.

Calyx bowl-shaped, invaginated at the base. IBB small, confined to basal concavity. BB wider than high, width 5.5 mm., height 2 mm. RR width 7 mm., height 3 mm. Both BB and RR ornamented with a low angular node. RR facets extending full width of RR plates, suture markedly gaping. The plane of the area is approximately horizontal but may slant slightly outward. The ligament areas cannot be exposed for study. The anal structures are not exposed to any of the three specimens we have available for study. Arms endotomous, ornamented with an angular longitudinal ridge. Pinnules long, slender. The anal sac rises to the full height of the arms and is apparently not recurved. It is ornamented with a single spine at its distal end. Column pentagonal, consisting of alternately expanded columnals. Whorls of cirri are given off throughout its entire length. These cirri overlap the calyx onto part of the arms. The cirri have been largely broken from the holotype.

This species can be readily distinguished from all others because of its large size. It is slightiy less angular in appearance than *L. wachsmuthi*, its nearest relative. *L. wachsmuthi* has a round column. It is fairly closely related to *L. praemorsus* from the Keokuk formation but can be distinguished in that it is larger in size and has a more typically bowl shape to the calyx.

Occurrence.—Pitkin limestone, north bank of Flower creek, 4½ miles northeast of Ft. Gibson, Oklahoma, in the center of sec. 19, T. 16 N., R. 20 E. This is the only species in our collections that does not occur in the lithographic limestone member near the middle of the formation. It occurs in the lower crinoidal limestone beds that lie near the base of the formation.

Types.—University of Tulsa, Holotype J-503. Paratype J-504,

Genus SCYTALOCRINUS Wachsmuth and Springer

SCYTALOCRINUS DUNLAPI Laudon, n. sp.

Plate 57, figure 1

Lower Carboniferous poteriocrinitids with arms branching only once, on or before the second Br, have been separated into two genera, *Decadocrinus* and *Scytalocrinus* by Wachsmuth and Springer (1879, p. 116, and p. 119). *Decadocrinus* is characterized by a

flaring saucer-shaped calyx with the IBB making a definite portion of the lateral wall and by exceptionally angular cuneiform Br in the arms that bear armlet-like ramules instead of ordinary pinnules. The genus *Scytalocrinus* included all other two-armed Poteriocrinitids in which the arms were rounded and bore ordinary pinnules. Within this genus were several quite variable more or less unrelated types. The establishment of the genus *Phanocrinus* by Kirk (1937, p. 602) partly solved this problem. There still remains within the genus *Scytalocrinus* considerable variation which may later warrant splitting the genus into at least three more genera. One of these would contain all forms with a conical calyx, and arms with short closely packed Br such as *S. validus* from the Keokuk formation. Another would contain forms with the rounded calyx in which the IBB still show on the lateral wall such as *S. dunlapi*, n. sp., *S. braggsi*, n. sp. The third would contain such forms as *S. fountainensis* and the form figured on plate 56, figure 5 of this report in which the first IBr is unusually long and is followed by long brachials throughout the arms. The genus *Melbacrinus* Strimple (Strimple, 1939) probably represents this latter type of *Decadocrinus*. However, since the genotype of *Melbacrinus* is so incomplete it will not be possible to make comparisons with related forms. It is probable also that all of these forms bearing long Br are immature individuals.

S. dunlapi, n. sp., is the largest known form of the genus, reaching a length of 158 mm. from the base to the arm tips. This species is represented by a single rather badly weathered specimen. Exact measurements on the calyx size are difficult because the calyx has been flattened on preservation. It is named in honor of its collector Mr. George Dunlap of Tulsa, Oklahoma.

Crown rounded, tubular, incurving slightly distally. Calyx cups apparently rounded, not conical. IBB small, showing only slightly on the lateral wall with only the tips projecting from beneath the rather large column. BB width 13 mm., height 7 mm. RR width 14 mm., height 7 mm. Ra in normal position, not elongated, in contact with pB and rpB beneath, laterally with X and rpB, supporting rt. X larger than RA, in contact with pB beneath, laterally with RA, rt, and lpR, supporting lt. RR facets occupying full width of RR plates, suture gaping, IBr axillary supporting unusually long arms. Br not cuneiform, short. Pinnules broken and badly weathered. Pinnulars short. Anal sac structure not observed.

S. dunlapi can be distinguished from all other species of *Scytalocrinus* by its unusual size. It also differs quite considerably from species of *Scytalocrinus* from the older Carboniferous formations in that it does not have the conical calyx form. It is undoubtedly transitional between the genus *Scytalocrinus* and *Phanocrinus*. The discovery of additional specimens in which the calyx plates and shape are better preserved may necessitate transfer of this species to the genus *Phanocrinus*.

Occurrence.—Pitkin limestone 1½ miles southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Types.—University of Tulsa, Holotype J-505.

SCYTALOCRINUS BRAGGSI Laudon, n. sp.
Plate 57, figure 3

This species of *Scytalocrinus* is characterized by unusually heavy arms with a rather peculiar cuneiform arm brachial structure and by a rounded rather high bowl-shaped calyx with the IBB forming a definite portion of the lateral wall. It is another form that is transitional between the genus *Scytalocrinus* and the genus *Phanocrinus*. It is represented in our collections by a considerable number of specimens, most of which are badly weathered.

Crown normally tubular and rounded. In the holotype the arm position has been distorted during preservation. Calyx bowl-shaped with the height almost equalling the width. Width 9 mm., height 6 mm. IBB relatively large, forming a definite part of the lateral wall. A definite basal concavity is developed in the IBB for reception of the proximal columnals. The IBB project downward over these columnals and then curve out and upward to make a conspicuous portion of the lower portion of the lateral calyx wall. BB slightly irregular, width 3 mm., height 3 mm. RR slightly variable in size, projecting downward and separated only slightly from the tips of the IBB. Width

of RR 3.5 mm., height 3 mm. Facet occupying full width of RR. Plane of area horizontal or slanting slightly inward. RA large, in normal position, resting on pB and rpB beneath, laterally in contact with X and rpR, only slightly smaller than rpR. X poorly exposed but in normal position, slightly larger than RA. Ibr axillary, wide, not constricted laterally or distally. Arms unusually thick and club-shaped. The arms are slightly flattened on the outside meeting the lateral wall with a distinct angle. They are distinctly cuneiform particularly in the upper portions. The food groove is broad and deeply excavated. The pinnules are unusually small for the size of the arms. Sac not preserved. Column round, consisting of alternately expanded columnals.

S. braggsi can be differentiated from other species of *Scytalocrinus* by its unusually thick club-shaped arms and its high bowl-shaped calyx with the invaginated base.

Occurrence.—Pitkin limestone 1½ miles southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Types.—University of Tulsa, Holotype J-506. Paratype J-507.

SCYTALOCRINUS GARFIELDI

Laudon, n. sp.
Plate 57, figure 2

This species of *Scytalocrinus* is characterized by a more normal type of calyx shape. It is broadly flaring saucer-shaped more like the type found in Decadocrinus. It is definitely progressive from the type shown in such forms as *S. hoveyi* (Worthen, 1875) where the calyx is sharply conical. It is a medium sized specimen measuring 31 mm. from the base of the calyx to the tips of the arms.

Crown slowly flaring and apparently not recurved distally. Calyx conical, broadly flaring, saucer-shaped. Width at RR tops 7.5 mm., height 3.5 mm. IBB small, definitely showing on lateral wall, only tips projecting from beneath column. BB height 2 mm., width 2 mm. RR width 3.5 mm., height 2 mm. Anal plates not available for study. Facets occupying full width of RR, gaping, plane of area slanting slightly outward. IBr conspicuously large, broad, with slight constriction at mid-length. Arms thick, club-shaped, very short, tapering rapidly at distal end, consisting of short quadrangular Br in proximal portion and slightly cuneiform pieces in the distal portion. Pinnules small. Sac unknown. Column round, consisting of alternately expanded pieces in the proximal portion. Distally the alternate pieces are greatly shorter. In the lower portion of the column there is little differentiation in the columnals.

S. garfieldi can be distinguished by its rapidly expanding, but not bowl-shaped calyx, coupled with its short stubby, thick, club-shaped arms.

Occurrence.—Pitkin limestone, 1½ miles southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Types.—University of Tulsa, Holotype J-508.

SCYTALOCRINUS sp.
Plate 57, figure 4

This illustrates a species of *Scytalocrinus* that occurs rather rarely in the Pitkin limestone. None of our specimens are well enough preserved to permit specific identification. It is characterized by the more primitive conical calyx and very slender arms in proportion to the size of the calyx.

Occurrence.—Pitkin limestone, 1½ miles

EXPLANATION OF PLATE 56

FIGS. *1, 2—Pelecocrinus stereosoma* Laudon n. sp. 1, Holotype, posterior, ×½, Univ. Tulsa J-500; *2*, Paratype, lateral view, ×½, Univ. Tulsa J-501. (p. 385)

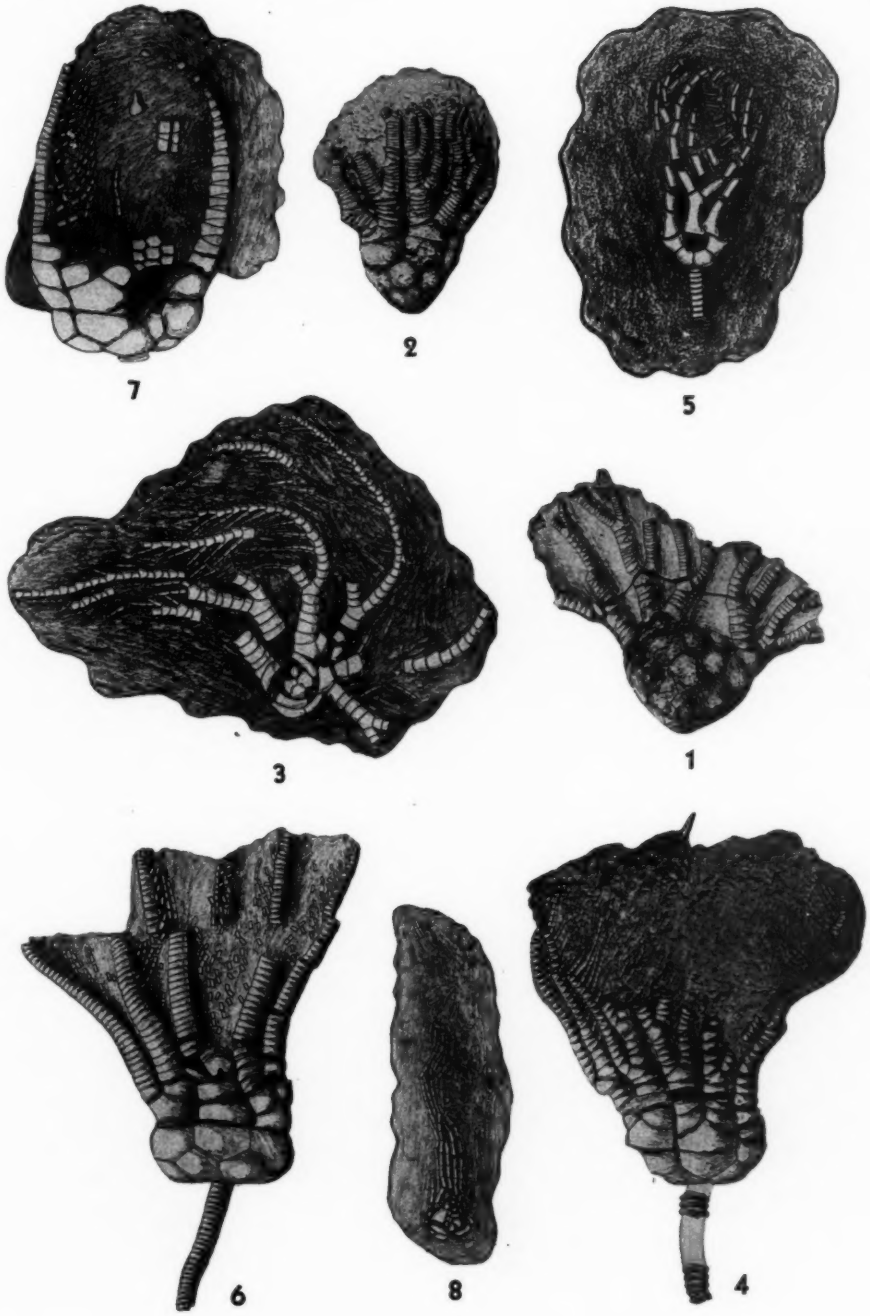
3—Cosmetocrinus sp. Incomplete specimen, figured for stratigraphic value, ×2, Univ. Tulsa J-502. (p. 386)

4—Linocrinus floweri Laudon, n. sp. Holotype, lateral view, ×1, Univ. Tulsa J-503 (p. 386)

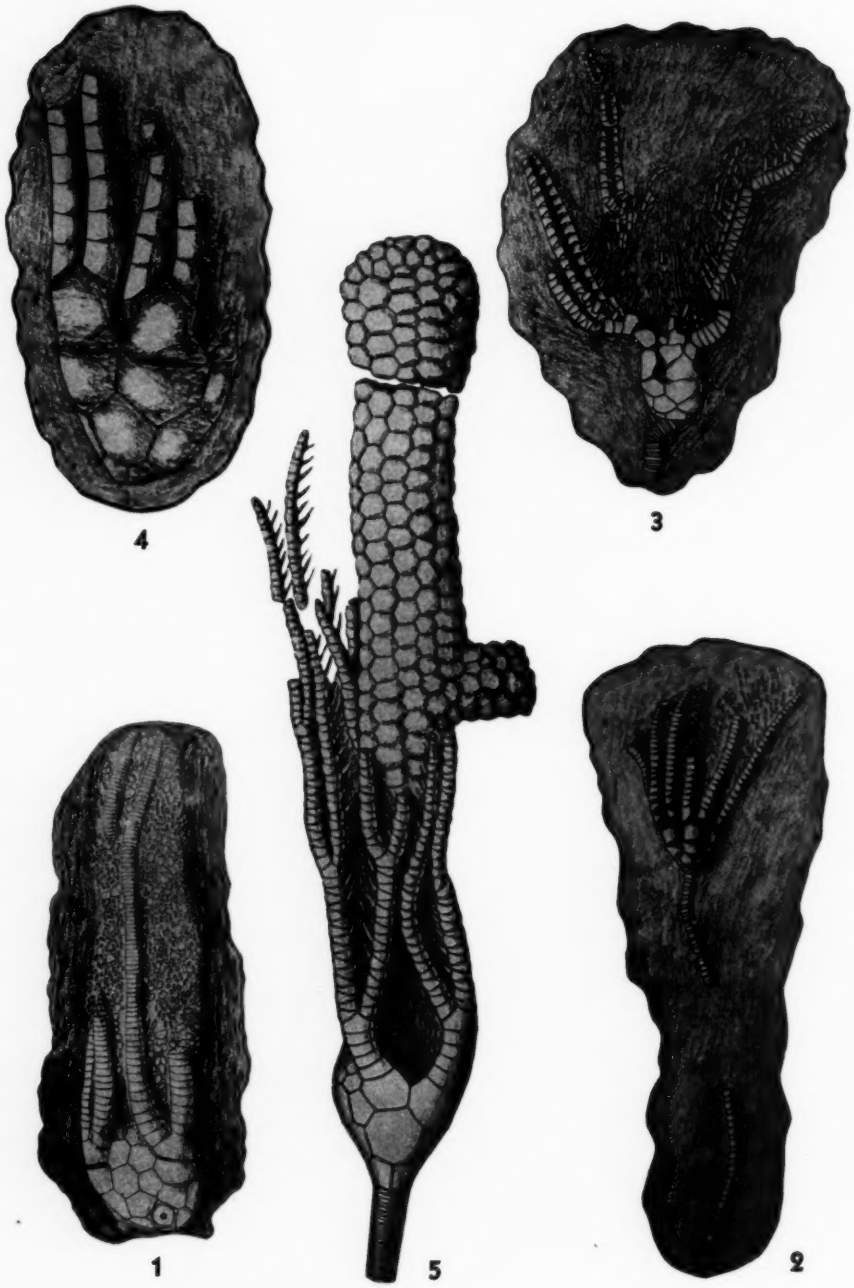
5—Scytalocrinus sp. Incomplete specimen characterized by unusually long IBr. ×2, Univ. Tulsa J-510. (p. 389)

6, 7—Phanocrinus cooksoni Laudon, n. sp. 6, Holotype anterior view, ×1, Univ. Tulsa J-511; *7*, Paratype, posterior aspect, ×1, Univ. Tulsa J-512. (p. 389)

8—Catillocrinus sp. Incomplete specimen figured for stratigraphic value. ×2, Univ. Tulsa J-515. (p. 390)



Laudon, Mississippian Crinoids



Laudon, Mississippian Crinoids

southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Figured specimen.—University of Tulsa collection J-509.

SCYTALOCRINUS sp.
Plate 56, figure 5

This small species of *Scytalocrinus* falls within the group that may be represented by the genus *Melbacrinus* (Strimple, 1939). It is very closely related to *S. similis* (Worthen, 1883) from the Chester beds of Monroe county, Illinois. If it differs at all, it is only in the length of the brachials of the upper arms. It is figured here for whatever stratigraphic value it may have. These species with the exceptionally long first brachial form a very definite group of Carboniferous crinoids and should certainly be separated from the genus *Scytalocrinus* providing they do not represent immature specimens.

Occurrence.—Pitkin limestone, 1½ miles northeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Figured specimen.—University of Tulsa collection J-510.

Genus PHANOCRINUS Kirk

PHANOCRINUS COOKSONI Laudon, n. sp.
Plate 56, figures 6, 7

The genus *Phanocrinus* was erected by Kirk in 1937 for species within the genus *Scytalocrinus* that had a low bowl-shaped calyx with the IBB small, and confined to a definite basal concavity. *P. cooksoni* illustrates the genus excellently. It is slightly above average size, measuring 56 mm. from the base to the arm tips. It is the most abundantly occurring form in the Pitkin fauna so we have a large number of specimens to study.

Crown expanding slightly above RR and recurving at tips. Calyx low, bowl-shaped, with a deeply invaginated base. Width 23 mm., height 5 mm., IBB very small, confined to deep basal concavity barely showing beyond the small column. BB forming the greater portion of the basal concavity and sharply recurved onto the lateral wall, distal points elongated far up between RR. RR much wider than high, width 13 mm., height 8 mm., quite variable in size. The two posterior RR are considerably smaller than the other three. pB elongated even more than others, truncated to support a small X plate. RA small, resting on pB and rpB beneath, the portion in contact with rpB small. Laterally in contact with X and rpR, supporting a very small rt above. X small, in contact with truncated pB beneath, laterally with RA, rt, and lpR. Sac small, short, rather inconspicuous, consisting of thin plates. It rises about two-thirds of the height of the arms. It is capped with a small spine. Facet occupying full width of RR, suture slightly gaping. IBr axillary, width 10 mm., height 6 mm. IIBr considerably larger than the others. Arms consisting of very short, quadrangular decidedly non-cuneiform pieces. Pinnules small, short. Column small, round. Columnals of equal size.

P. cooksoni can be distinguished from all other species of the genus *Phanocrinus* in that it has a lower, broader, more characteristically bowl-shaped calyx than any species as yet described. It is considerably more robust than any of the other forms and its arms tend to be proportionately shorter. It is perhaps most closely related to *P. calyx* from the lower Carboniferous of Scotland (Wright, 1939).

Occurrence.—Pitkin limestone, 1½ miles southeast of Hulbert, Oklahoma, in the road-cut on the face of the fault line scarp, in the SE ¼, sec. 27, T. 17 N., R. 20 E. Paratype J-512, 1½ miles southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Types.—University of Tulsa, Holotype J-511. Paratypes J-512, J-513.

EXPLANATION OF PLATE 57

FIGS. *1*—*Scytalocrinus dunlapi* Laudon, n. sp. Holotype, Posterior view, ×½, Univ. Tulsa J-505 (p. 386)
2—*Scytalocrinus garfieldi* Laudon, n. sp. Holotype, Lateral view, ×1, Univ. Tulsa J-508. (p. 388)
3—*Scytalocrinus braggsi* Laudon, n. sp. Holotype, lateral view, ×1, Univ. Tulsa J-506. (p. 387)
4—*Scytalocrinus* sp. Incomplete specimen figured for stratigraphic value. ×2, Univ. Tulsa J-509. (p. 388)
5—*Carcinocrinus stevensi* Laudon n. sp. Holotype, Right Lateral view, ×1, Univ. Tulsa J-514. (p. 390)

Genus CARCINOCRINUS Laudon, n. gen.

Genotype: *Carcinocrinus stevensi* Laudon, n. sp. Pitkin Limestone, Hulbert, Oklahoma. Genotype, University of Tulsa J-514.

This unusual, bizarre form represents one of the most highly specialized genera of the Poteriocrinitidae. The shape of the calyx and structure of the arms shows it to have evolved through *Culmicrinus*. It is characterized by a sharply conical calyx, with the IBB forming a definite portion of the lateral wall. Arms branching isotomously in the same manner as in *Culmicrinus*. Most outstanding is an enormously overdeveloped anal sac with the opening directed through a lateral spout about midway up the sac. The arms are small and flimsy in comparison to the sac. They undoubtedly did not reach the full length of the sac.

Generic description.—Crown rounded, tubular calyx sharply conical, IBB making a definite portion of lateral wall. RA in normal position in contact with pB and rpB beneath, laterally with X and rpB, supporting rt. X in normal position, resting on truncated pB beneath, laterally in contact with RA, rt, and lpR, supporting lt. Facets considerably less than greatest width of RR. Facets directed outward and upward, area definitely slanting outward. First IBr definitely directed outward. Arms curving upward after third IBr. Arms uniserial, cuneiform, slender, rounded, branching isotomously, at least three times. In the rp and ra rays they branch the first time on the fifth IBr. The position of branching is apparently irregular in the upper arms. Pinnules short, slender. Sac unusually strong, rising above arms, expanded at distal end, anal opening from a laterally directed spout midway up on anterior side. Column round.

CARCINOCRINUS STEVENSI Laudon, n. sp.
Plate 56, figure 5

Carcinocrinus stevensi is one of the largest forms ever described in the Poteriocrinitidae. It measures 137 mm. from the base to the top of the anal sac.

Calyx sharply conical, width 19 mm., height 22 mm. IBB erect forming a definite portion of the lateral wall, width 4 mm., height 5 mm., BB width 8 mm., height 9 mm. RR curved, laterally making a lobed appearance at arm bases, width 10 mm., height 6 mm. Facets occupying a considerably constricted upper portion of RR. RA smaller than BB or RR, in normal position, in contact with pB and rpB beneath, laterally with RA, rt, and lpR, supporting lt. IBr smaller than RR, IBr_6 axillary in rp ray. Other arms not exposed for study. Arms slender, uniserial, IBr quadrangular, others cuneiform. Arms branch isotomously at least three times. $IIBr_{18}$ axillary in rp ray. Irregular above that. Sac unusually strong, rising above arms, length 113 mm., width at mid-length 14 mm., width at expanded distal portion 19 mm. Several pits on distal portion suggest that the form may have carried spines on the end of the sac. Anal opening at the end of stout laterally directed about which projects 9 mm. beyond sac on anterior side. Spout at approximately the mid-length. Column round.

This genus is named in honor of its collector Mr. Robert Stevens of Tulsa, Oklahoma.

Occurrence.—Pitkin limestone, ½ mile southeast of Hulbert, Oklahoma, in the road cut on the face of the fault line scarp, in the SE ¼, sec. 27, T. 17 N., R. 20 E., Muskogee quadrangle.

Types.—University of Tulsa, Holotype J-514.

Genus CATILLOCRINUS Wachsmuth and Springer

CATILLOCRINUS sp.
Plate 56, figure 8

This specimen of *Catillocrinus* is figured for whatever stratigraphic value it may have. It is too poorly preserved for specific identification. The calyx is badly broken and some plates are missing. It is a very small specimen measuring only 24 mm. from the base to the arm tips. It is probably fairly closely related to *C. carpenteri* (Springer, 1923).

Occurrence.—Pitkin limestone, 1½ miles southeast of Garfield, Oklahoma, in the NE ¼, sec. 16, T. 14 N., R. 21 E., Muskogee quadrangle.

Figured specimen.—University of Tulsa, J-515.

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AN ONTOGENETIC STUDY OF SOME RUGOSE CORALS FROM THE HAMILTON OF WESTERN NEW YORK

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ABSTRACT—Nine species of rugose corals are described and illustrated, and their ontogenetic development is discussed. The new genus, *Stewartophyllum*, and the new species, *Caninia complexa*, *C. tabulata*, *Barrandeophyllum reimanni*, *B. Simplex*, *Alleynia americana*, and *Hapsiphyllum bifurcatum* are described. *Stereolasma rectum* (Hall) and *Amplexus hamiltoniae* Hall are also described.

PRIMITIVE ancestral traits found in the ontogeny of all rugose corals establish a firm basis for an approach from a phylogenetic standpoint. A good example of the use of ontogenetic development may be found in species of the genus *Amplexus*, which, in the young stages, exhibit the typical quadripartite septal arrangement of the Streptelasmidae, but in the adult stage the septa become radially arranged. Since ontogenetic studies have been in progress, it has been possible with a fair degree of accuracy to establish phyletic relationships that previously had been in many cases a matter of conjecture.

The rugose corals treated in this paper and collected from the Hamilton of western New York are referable to five different families: Petraiidae, Streptelasmidae, Zaphrentidae, Laccophyllidae, and Hapsiphyllidae. No doubt further study will reveal additional forms.

Two genera previously not known to be present in the Devonian of this continent have been recognized, both belonging to the family Laccophyllidae Grabau. They are *Barrandeophyllum*, represented by two previously undescribed species, and *Alleynia*, represented by one previously undescribed species. Species of the genus *Alleynia* have been described by Počta from the Middle Devonian rocks of Bohemia. The American genus *Laccophyllum*, which Grabau considers to be congeneric with *Alleynia*, is Middle Devonian in its range, in common with most of the Bohemian species. Grabau, likewise, believes that both American and European species are derivatives of the same boreal stock because the Middle Devonian was an epoch when the boreal coral fauna was widespread in Europe and America. It is, therefore, not surprising to find representatives of the genus *Alleynia* in this country.

Počta (1902, p. 190) created the genus *Barrandeophyllum* for a small species of simple coral from the Lower Devonian of Bohemia. Grabau (1928, pp. 88–95) has described three species belonging to this genus, all of which are Lower Carboniferous in age and were found in the Dinantian (Viséan) of China.

The present treatment deals only with species of rugose corals from the Wanadah and Windom members of the Ludlowville and Moscow formations respectively. Many rugose corals are present in the Centerfield and Tichenor members also, but they have not been studied in detail. These unstudied corals are silicified, and their structures are not so well preserved as in the shaly members. The Ledyard member of the Ludlowville formation contains very few fossils of any kind apart from the upper six-inch "*Strophalosia* bed," and no corals have been collected from this member.

Many of the corals, as well as other fossils of the Wanadah and Windom members, are slightly compressed or flattened due to compaction after burial, but the structures within the thecarium rarely are destroyed. They are generally calcified, and commonly slightly pyritized.

The following list shows the classification of Hamilton divisions:

Hamilton group
- Moscow formation
  - Windom member
- Ludlowville formation
  - Tichenor member
  - Wanakah member
  - Ledyard member
  - Centerfield member
- Skaneateles formation
- Marcellus formation

TABLE 1.—STRATIGRAPHIC DISTRIBUTION OF THE CORALS IN THE WINDON AND WANAKAH MEMBERS

Species	Windom	Wanakah
Stewartophyllum, n. gen., *intermittens* (Hall)	×	×
Stereolasma rectum (Hall)	×	×
Amplexus hamiltoniae Hall	×	×
Caninia complexa Busch	?	×
Caninia tabulata Busch	×	
Barrandeophyllum reimanni Busch	×	×
Barrandeophyllum simplex Busch	?	×
Alleynia americana Busch	×	?
Hapsiphyllum bifurcatum Busch	×	×

This study was suggested by Mr. Irving G. Reimann of the Buffalo Museum of Science, and the writer is especially grateful to him for his continued interest in the progress of the work.

Appreciation is also due to Dr. Grace A. Stewart of Ohio State University for her supervision of the research and the critical examination of the finished paper. Acknowledgments are also extended to Dr. John Wells, also of Ohio State University, for his helpful criticism of the manuscript. The figures of the coral sections are drawings made by the writer, and they all are oriented with the cardinal septum at the top. All of the types are in the Geological Museum, Orton Hall, Ohio State University.

List of localities

1.—Wanakah shale exposure where Berg road crosses Smoke creek, two miles east of West Seneca and one mile southeast of the city limits of Buffalo.

2.—Wanakah shale (*Pleurodictyum* beds) exposure at the old Bay View quarry, located at a point four miles south of the city limits of Buffalo and one mile east of the lakeshore.

3.—Windom member of the Moscow, exposed along Morse creek near Athol Springs four and one-half miles south of the city limits of Buffalo.

SYSTEMATIC DESCRIPTIONS

Class ANTHOZOA Ehrenberg

Subclass RUGOSA Milne-Edwards

Family PETRAIIDAE de Koninck (emend. Grabau)

Genus STEWARTOPHYLLUM Busch, n. gen.

Genotype.—Amplexus intermittens HALL, *1876* New York Nat. Hist. Survey, pl. 32, figs. 8–13,

The corallum is simple, small, rapidly expanding, and slightly curved. The septa are pinnately arranged on the floor of the calice. Septa reach the center, but are not fused at their inner ends. The septa zigzag in the immature portions of the corallum, but are straight in the mature part. They retain their pinnate arrangement throughout the ontogeny.

The genus *Stewartophyllum* fits Grabau's designation of the petraiids in more respects than any other family of the Rugosa. It differs, however, in that there is one prominent tabula at the base of the calice and there is no evidence of secondary (tertiary of Grabau) septa. The notably primitive aspect of the genus, evidenced by the absence of a columella and dissepiments, is deemed sufficient reason to provisionally include it in the family Petraiidae, rather than establish a new family based on a single genus.

The three genera previously referred to the family Petraiidae are *Petraia* Münster, *Orthophyllum* Počta, and *Paterophyllum* Počta. The new genus *Stewartophyllum* is similar to the Devonian forms of the genus *Petraia* in that the maximum diameter of the calice is similar to that of the height, but differs in being only half the average size of *Petraia*. *Stewartophyllum* shows a more advanced stage of evolutionary development than *Petraia*. The septa, instead of being fully developed in only the basal one-fifth of the corallum, reach nearly to the center throughout the height of the thecarium. The major septa are readily distinguished and the counter quadrants are accelerated, two features which cannot be determined in the case of *Petraia*.

Stewartophyllum differs from *Orthophyllum* Pôcta in much the same respects as it does from *Petraia*. An additional distinguishing characteristic, however, is the retention of the primitive quadripartite arrangement of the septa throughout the ontogeny of *Stewartophyllum*. The septa are radially disposed in the mature portion of *Petraia*.

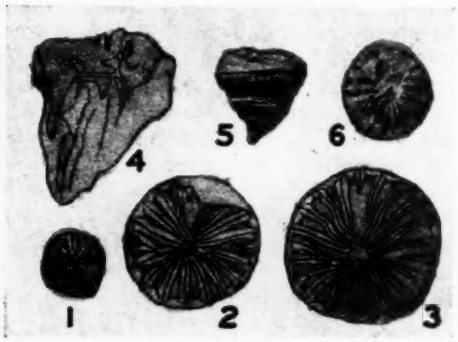
One of the external differences between *Stewartophyllum* and *Paterophyllum* Počta is the usually erect, turbinate character of the latter. The calicinal diameter may equal or even exceed twice the height. Secondary (tertiary of Grabau) septa are well developed in *Paterophyllum* and are absent in *Stewartophyllum*.

The genus *Stewartophyllum* is named in honor of Dr. Grace A. Stewart, Associate Professor of Geology, Ohio State University.

STEWARTOPHYLLUM INTERMITTENS (Hall)
Figures 1–6

Strombodes sp.?, HALL, *1843*, New York Nat. Hist. Survey, pt. 4, Tables of Organic Remains, no. 49, figs. 2, 2a.
Amplexus intermittens HALL, *1876*, New York Nat. Hist. Survey, pl. 32, figs. 8–13.

External characters.—Corallum simple, small, straight to slightly curved, turbinate. Average observed size, 12 mm. high, and 10.5 mm. in diameter. Epitheca plainly exhibits septal grooves and interseptal ridges, and a slightly irregular surface produced by annular growth lines. Two of the specimens



FIGS. *1–6—Stewartophyllum intermittens* (Hall) *1–3*, Serial sections, ×2; *4*, longitudinal section of a hypotype, ×2; *5*, hypotype of Hall's *Amplexus intermittens; 6*, calice view of the same specimen showing the pinnate character of the septa. Specimen nos. 18751a, b, c, 18752, and 18753 in the Geological Museum, Orton Hall, Ohio State University.

are almost cylindrical in the apical portion, but rapidly expand a millimeter or so from this proximal end. Walls of the calice not preserved; pinnate arrangement of the septa clearly seen on floor of the calice; secondary septa absent.

Internal characters.—In the neanic stage (fig. 1), the four major septa are distinguishable from the other primaries. The septa are pinnately arranged and fail to reach the center. They are zigzag and appear as threads, with the secondary thickening attaining a maximum of half the width of the interseptal spaces. The haphazard septal arrangement results in several pseudofossulae. Primary septa number 16; secondary septa and dissepiments are absent.

In early maturity the cardinal septum retreats rapidly from the central area. A fusion of the first and second primary septa of the cardinal quadrants at a position midway between the center of the corallum and the outer wall results in the development of a prominent cardinal fossula. The septa retain their pinnate arrangement throughout the ephebic stage, but are not as zigzag as in the neanic stage. A distinct lack of fusion of the stereoplasm of the septa with that of the epitheca is characteristic. There are three septa in the left cardinal and four in the right cardinal quadrants of this specimen (figs. 2 and 3). Each of the counter quadrants contains five septa. The presence of a fourth septum in the right cardinal quadrant of this specimen is probably an individual variation. In late maturity the septa retreat slightly from the central area and are not of equal length. The septal ends are thus left gaping. The cardinal septum retreats until it is no longer visible, but the inward-pointed projection of stereoplasm indicates its rudimentary existence.

A longitudinal section (fig. 4) shows but one tabula. This forms a flat, elevated platform in the floor of the calice, and bends abruptly in the vicinity of the outer wall in the direction of the apex. It feathers out, however, on both sides halfway between the two bending places and the peripheral margins. This longitudinal section was cut parallel to the plane of the cardinal and counter septa and thus shows a pointed projection of the tabula in the vicinity of the cardinal fossula. Cystose and other endothecal structures are entirely absent.

The foregoing description is based on three incomplete specimens.

Remarks.—This species was first figured by Hall as *Strombodes sp.?* and was later figured as *Amplexus intermittens.* In the writer's opinion this species does not fit the requirements of the genus *Amplexus* any better than *Strombodes. Strombodes* is a colonial coral, increasing by calicular gemmation. The genus *Amplexus* is characterized by highly developed tabulae and septa which fail to reach the center. From the foregoing description, it is quite evident that none of the distinguishing features of

these two genera will apply to the specimens just described. The most pronounced and characteristic feature of this species is the retention of the pinnate relationship of the septa throughout the ephebic stage.

Horizon and locality.—Locality 1.

Hypotypes.—Nos. 18751 a, b, and c, 18752, and 18753, Geological Museum, Ohio State University.

Family STREPTELASMIDAE (emend. Grabau)

Genus STEREOLASMA Simpson

Genotype.—Strombodes? rectus HALL, *1843*, New York Nat. Hist. Survey, pt. 4, pp. 209, 210, fig. 5.

The genus *Streptelasma* was established by Hall to include a simple rugose coral which differed from *Cyathophyllum* in the structure of the wall, which is destitute of an epithecal covering, and is covered by sublamellar costae.

Simpson in 1900 (pp. 205–206) separated the genus *Stereolasma* from *Streptelasma* on the difference in the character of the pseudocolumella. In *Stereolasma* the pseudocolumella is formed by a deposit of stereoplasm about the inner ends of the septa, whereas in *Streptelasma* the pseudocolumella is the result of the twisting of the inner ends of the septa. Simpson points out and Grabau (1922, pp. 30–31) emphasizes the development of the cardinal septum. The development of a fossula is common to the genera *Zaphrentis*, *Stereolasma*, and *Lopholasma*, the latter two of which belong to the family Streptelasmidae. Grabau points out the lack of generic relationship between *Zaphrentis* and *Stereolasma*, and bases his conclusions on the different periods of development of the fossula. *Zaphrentis* and its associated genera have this feature developed at a very early period, whereas it appears much later in the ontogeny of *Stereolasma* and *Lophophyllum*.

Another distinctive difference between *Stereolasma* and *Zaphrentis*, brought out by Grabau, is the accelerated condition of the counter quadrants in the former and the usual acceleration of the cardinal quadrants in the latter. In primitive species of *Zaphrentis* the quadrants are nearly equal, as they are in the primitive Streptelasmidae. In *Stereolasma* the four major septa appear in the earliest neanic stage, and the other primaries are almost as early in their appearance. Quadripartite septal arrangement and alar pseudofossulae are prominent features of the neanic stage. The septa assume a radial arrangement in the ephebic stage. Dissepiments appear late and are never abundant.

STEREOLASMA RECTUM (Hall)

Figures 7–16

Strombodes? rectus HALL, *1843*, Nat. Hist. Survey of New York, pt. 4, pp. 209, 210, fig. 5.

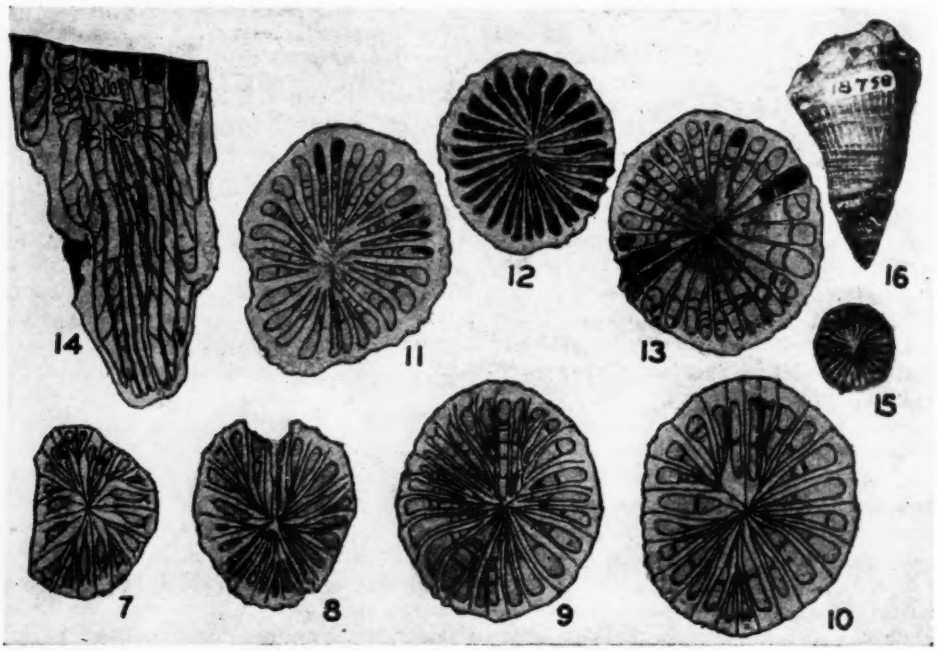
Streptelasma rectum (BROWN), *1907*, Am. Jour. Sci., vol. 23, p. 277, figs. 1–13.

External characters.—Corallum simple, small, slightly curved, trochoid, expanding at more or less uniform rate from apex upwards. A few specimens in the collection studied expand quite irregularly in the apical and median portions. All sections above the apical portion subelliptical in cross section as a result of compression. Maximum observed size, 29 mm. high, 19 mm. and 13 mm. being the maximum and minimum dimensions across the calice of the same individual; average 25 mm. by 15 mm. by 12 mm. Epitheca clearly exhibits septal grooves and crowded growth lines; positions of the four major septa easily seen on the exterior. Many specimens exhibit a talon-like process in the apical portion, which evidently served the purpose of anchoring. Calice of moderate depth, but calicular edge is usually broken away, so that entire depth cannot usually be determined. Septa for the most part are radially arranged. Fossula may or may not be pronounced, depending largely on condition of preservation. Dissepiments are sometimes observable in the calice view. Secondary septa (not always observable in the calice) are slightly better developed in the cardinal quadrants than in the counters. The external dimensions vary considerably.

Internal characters.—Primary septa appear in earliest stage of ontogeny. They have a primitive quadripartite arrangement throughout all of the neanic stage. The progressive phases of the neanic stage are illustrated on figures 7–12. In the neanic stage the cardinal, counter, and alar septa meet approximately in the center of the corallum and are a trifle longer than any of the other primary septa. The cardinal septum has the

same amount of secondary thickening as the other primary septa in the neanic stage, but it becomes comparatively thinner in the adult stage. It occupies the entire length of a medium-sized fossula, which is difficult to distinguish in some sections. The neanic stage is characterized by a maximum of 26 well-developed primary septa. There are four septa in each of the right and left either side of the counter septum (figs. 10–12). In some specimens they pull away from the counter septum in the ephebic stage (fig. 13).

The septa have a radial arrangement in the ephebic stage, except for the partial fusion in the center of their inner ends. The development of the fossula, by the abortion of the cardinal septum, is the chief criterion



FIGS. *7–16—Stereolasma rectum* (Hall). *7–13*, Serial sections; *7*, ×6; *8*, *9*, ×4; *10*, *11*, ×3; *12*, ×2; *13*, ×3; *14*, longitudinal section of a hypotype, ×2; *15*, calice of a hypotype with the sides broken away; *16*, lateral view of a different specimen. Specimen nos. 18754a, b, c, d, e, f, 18755, 18756, 18757, and 18758 in the Geological Museum, Orton Hall, Ohio State University.

cardinal quadrants which fuse at their inner ends to form the fossular wall on either side of the cardinal septum. There are six septa on either side of the counter septum in each of the counter quadrants. This means that there are six septa between the counter septum and each of the alar septa. In most sections the alar pseudofossulae are not as readily recognized as the cardinal fossula. Dissepiments appear early, and rapidly increase in number up to a maximum of five for each interseptal space, three being the average. In the late neanic stage one pair of accelerated secondary septa appears on for this stage of the ontogeny. The insertion of the secondary septa is preceded by a thickening of the primary septa where they join the theca. In figure 13 every primary septum, with the exception of the cardinal septum, is thickened or else split in the vicinity of the thecal wall, thus indicating the formation of the secondary septa by the bifurcation of the primaries. Grabau (1922, p. 33) states that the secondary septa are of moderate length and longer in the cardinal than in the counter quadrants. There seems to be little basis for differentiating between the lengths of the septa occurring in these

two sets of quadrants, if we except the two secondaries on either side of the counter septum and those seen in the calice. The dissepiments are as abundant in the ephebic as in the neanic stage and they even bridge the interseptal spaces between the primary and secondary septa where the latter are well developed. Toward the end of the ephebic stage the cardinal septum atrophies at its inner end, thus indicating the position of the fossula. Tabulae are well developed and clearly visible in the longitudinal section.

Remarks.—Thirty-two sections have been made from various specimens of this species. Many of them are difficult to orient because of the marked similarity between the four major septa and the rest of the primaries. In some of the sections the inner ends of the primary septa become aborted, but there is apparently no special significance attached to this atrophy. It probably is the result of the accidental withdrawal of one or more of the folds at the base of the fleshy polyp.

External characters will not serve to differentiate between *Stereolasma rectum* and the type species of the genus *Lopholasma*, which is *Streptelasma rectum* Hall 1876 (in part). One must rely wholly on internal differences. There are strong, essentially horizontal carinae on the sides of the septa of the genus *Lopholasma*. These are easily recognized in sections as curved, spur-like processes which project from the sides of the septa. They are absent in *Stereolasma rectum*.

Diagnostic characters for this species are summed up as follows: pinnate arrangement of the septa throughout the neanic stage; radial arrangement of the septa in the ephebic stage; acceleration of one pair of secondary septa on either side of the counter septum in the late neanic stage; development of a cardinal fossula by the abortion of the cardinal septum in the most mature portion of the corallum, just below the calice; and stereoplasmic thickening of the cardinal septum less than that of the other septa in the ephebic stage.

Horizon and locality.—Locality 2. This species is also known from the upper Hamilton (upper Traverse) beds of Alpena and near Petosky, Michigan; Cedar Valley limestone of Iowa; and Mid-Devonian beds of Tunghsan, Kutsing district, Yunnan Province, China.

Hypotypes.—Nos. 18754a, b, c, d, e, and f. 18755, 18756, 18757, and 18758, Geological Museum, Orton Hall, Ohio State University.

Genus AMPLEXUS Sowerby

Amplexus SOWERBY, *1814*, Mineral Conchol., t. 1, p. 165.
Cyathopsis D'ORBIGNY, *1850*, Prodrôme de Paléont. Stratigraphique, t. 1, p. 105.
Genotype.—Amplexus coralloides SOWERBY, *1814*, Mineral Conchol., t. 1, p. 165.

Edwards and Haime (1850, p. 66) sum up the characteristics of this genus as follows:

> Corallum resembling *Zaphrentis* except that the septa do not extend to the center of the visceral chamber, and leave the upper surface of the tabulae naked and smooth in that part. The septal fossula is well characterized in the upper portion of the corallum, but not so on the lower floors. Tabulae highly developed.

Grabau (1922, p. 61) feels that the septal fossula is an incipient siphonofossula which occurs only in some specimens and then in the adult portions of accelerated individuals. It is entirely absent in the neanic stage. He summarizes the essential characters of this genus as follows:

> The cylindrical form above the rapidly tapering initial portion; the thin equally developed septa, which are widely spaced and do not extend beyond the marginal portion of the corallum; and the well developed and numerous tabulae which extend entirely across the corallum in a more or less regular manner and are close together. The septa extend as narrow ridges upon the outer margins of the tabulae.

AMPLEXUS HAMILTONIAE Hall
Figures 17–27

Amplexus hamiltoniae HALL, *1876*, New York Geol. Survey, pl. 19, figs. 20–23; GRABAU and SHIMER, *1909*, North American index fossils, vol. 1, p. 59, fig. 86.

External characters.—Grabau and Shimer (1909, p. 59) sum up the characteristics of *Amplexus hamiltoniae* as follows:

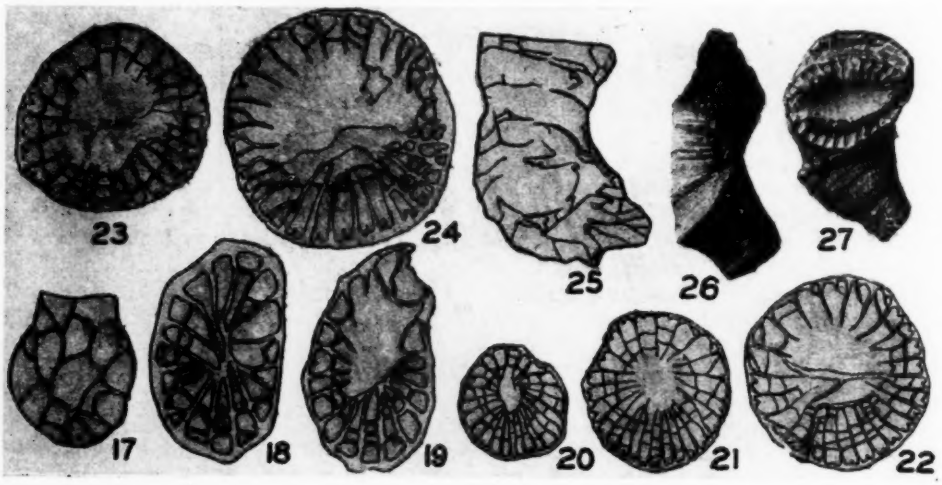
> Small, cylindrical, often abruptly bent and constricted. Strong distant septa reach about a third to the center, and stop abruptly. Tabulae flat.

Repeated contractions followed by expansional growth, together with abrupt changes in direction of growth are characteristic of this New York species. The proximal end, as well as the sides of the calice, is

usually broken, hence length measurements vary considerably. Average observed size, 23 mm. high, 13.5 mm. in diameter. Epitheca thin and commonly worn off, thus exposing the peripheral ends of the septa. Longitudinal ridges are preserved on all specimens and fine growth lines can be seen when the epitheca is well preserved. Septa are radially arranged and are approximately one-third the diameter of the calice in length. Depth of the calice is not known because the sides are always broken away.

making a total of 16 septa in the neanic stage (fig. 18). Secondary septa do not appear in this early stage. Dissepiments are formed from the very beginning, there being no more than two in any of the interseptal spaces. There is no indication of a cardinal or counter fossula, but the alar pseudofossulae are fairly distinct.

The change toward an amplexoid structure marks the termination of the neanic stage, and the initial phase of the ephebic. The inner ends of all of the septa begin to



FIGS. *17–27—Amplexus hamiltoniae*, Hall. *17–25*, serial sections; *17*, ×8; *18*, ×6; *19*, ×4; *20–24*, ×2; *25*, longitudinal section of a hypotype, ×2; *26*, a hypotype exhibiting irregular growth; *27*, combined lateral and calice view of a different specimen. Specimen nos. 18759a, b, c, d, e, f, g, h, 18760, 18761, and 18762 in the Geological Museum, Orton Hall, Ohio State University.

Secondary septa in one-half of the calice are usually observable. Orientation on external evidence is very difficult.

Internal characters.—The neanic stage of *A. hamiltoniae* is quite brief. Primary septa with a marked pinnate relationship appear in earliest immaturity (fig. 17). Diagnostic characters for the neanic stage are the meeting of the major septa in the center of the corallum and the quadripartite arrangement of the remainder of the primaries, with the latter being a typical streptelasmoid character. There are three primary septa between the cardinal and alar septa in each of the cardinal quadrants. In the counter quadrants there are also three primary septa on each side of the counter septum, thus

retreat from the center of the corallum at about the same time and withdraw at a fairly uniform rate as the corallum enlarges. Any semblance of alar pseudofossulae is destroyed by the abortion of the inner ends of the septa and the concomitant partaking of a radial symmetry. Thus it is impossible to determine accurately the number of septa in the respective quadrants. There is, however, a maximum of 26 primary septa in the ephebic stage (fig. 22). The counter septum, instead of the usual cardinal septum, is distinctly aborted in the latest stages of the ontogeny of *A. hamiltoniae*, and this results in the formation of a counter pseudofossula. Secondary septa appear first in the ephebic stage as very slight elevations of the theca

between the bases of the primaries. In full maturity (fig. 24) they become pointed, but never attain a length greater than one-fifth that of the primaries. The interseptal spaces of the counter quadrants are noticeably smaller and contain more dissepiments than the interseptal spaces of the cardinal quadrants (figs. 20–23). In figure 24, the dissepiments have decreased in number and the primary septa extend approximately one-third the distance to the center. The sections cut just above the tabulae through this portion of the corallum are somewhat longer.

Tabulae do not appear until late in the neanic stage. The tabulae in the ephebic stage are very well developed and extend all the way across the corallum as shown in the longitudinal section, figure 25. They form broad U-shaped arches, the convex sides being toward the calice.

Remarks.—The extremely abrupt bendings and the constrictions, together with the small size, are almost diagnostic external characters of this species. The flat tabulae and short septa characterize the internal structure of *A. hamiltoniae.*

The streptelasmoid character of the neanic stage of this species may be recognized in figure 25. This longitudinal section has been cut across the joined inner ends of the septa, hence the restricted, longitudinal structures in the apical portion of the section.

The sections described above were made from three different specimens. The apical ends of mature specimens are usually broken and those specimens that do have the apical end preserved are not usually developed beyond the middle ephebic stage.

Horizon and locality.—Locality 2. Grabau (1898, p. 124) says, "Found frequently in the Moscow shale, three to five feet above its base, . . ."

Hypotypes.—Nos. 18759a, b, c, d, e, f, g, and h, 18760, 18761, and 18762, Geological Museum, Orton Hall, Ohio State University.

Family ZAPHRENTIDAE Milne-Edwards and Haime (emend. Grabau)

Genus CANINIA Michelin

Caninia MICHELIN, *1840*, Congrès de Turin, Dictionnaire des Sciences Naturelles, Supplement I, p. 485; ——, VAUGHAN, *1903*, Bristol Nat. Soc. Proc., n. s., vol. 10, p. 102; ——, CARRUTHERS, R. C., *1908*, Geol. Mag., dec. 5, no. 5, pp. 20–21, 63–74, 158–171, pls. 4, 5, and 6; ——, O'CONNELL, *1914*, New York Acad. Sci. Annals, vol. 23, pp. 177–192.

Cyathopsis d'ORBIGNY, *1850*, Prodrôme de Paléont. Stratigraphique, t. 1, p. 105.

Genotype.—*Caninia cornucopiae* MICHELIN, loc. cit.

This genus was discarded by Milne-Edwards and Haime, de Koninck, Nicholson, and others because the first mention of the genus in "Iconographie Zoophytologique" was not accompanied by a description.

Carruthers examined *C. cornucopiae* and allied forms in the English Viséan and redefined the genus as follows:

> Corallum simple, turbinate and conical, often slender and cylindrical for a great part of its length.
>
> Major septa well-developed and meeting in the center in the lower, conical part of the coral, but in the cylindrical portions usually becoming amplexoid in character.
>
> Minor septa of various lengths in different species.
>
> Cardinal fossula variable in extent, characteristically limited by tabulae only, at the inner end, and with the flanking septa loose or disconnected.
>
> Tabulae well-developed, but variable in regularity; they may be highly arched and visceral. A marginal ring of more or less vertical dissepiments, usually thin and delicate, intervenes in the mature stages of growth between the tabulae and wall.

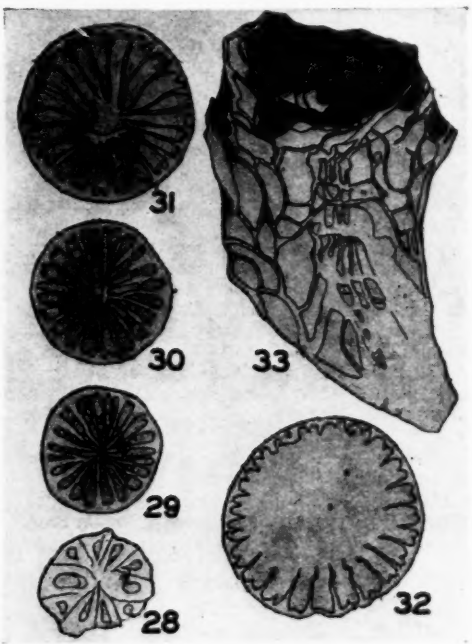
CANINIA COMPLEXA Busch, n. sp.
Figures 28–33

External characters.—Curved trochoid corallum which expands at a fairly uniform rate. Average observed size 29 mm. high, and 15 mm. in diameter. Longitudinal ribbing is faint. Close inspection reveals fine growth lines. The calice is of moderate depth and completely filled in the specimens of my collection. A specimen measuring a little over an inch in length has a maximum diameter of about five-eighths of an inch. The cross-section of this species is usually circular. External ridges on the surface, which vary in distinctness, indicate the positions of the interseptal spaces within the thecarium between the primary and secondary septa.

Internal characters.—The major septa are difficult to distinguish from the other primaries in the early neanic stage (fig. 28). The septa number ten, are extremely over-

thickened by stereoplasm, and are pinnately arranged in four groups. Pseudofossulae are indistinct and dissepiments are absent.

The late neanic stage is indicated by figure 29. The primary septa attain their maximum number of 22. The cardinal quadrants contain four and the counter quadrants five primary septa respectively. Although there is a tendency toward radial symmetry in the late neanic stage the pinnate arrangement of the septa still predominates. The fourth, and last, of the cardinal septa to appear are somewhat retarded in their growth and form the sides of what will be the cardinal fossula in the ephebic stage. They are half as over-thickened as the other primaries and extend only half way toward the center where they become fused with the third septa of the cardinal quadrants. The cardinal septum, which extends the entire length of the space between the cardinal septa, loses much of its secondary thickening in late youth. Secondary septa reach almost their maximum stage of development in the late neanic stage. Dissepiments number from one to four, two being common. Alar pseudofossulae are indicated by the contrast between the pinnate arrangement of the most youthful counter primary and the radial position of the two alar septa.



FIGS. *28–33—Caninia complexa* Busch, n. sp., *28–32*, serial sections; *28*, ×4; *29–32*, ×2; *33*, longitudinal section of a syntype, ×2. Specimen Nos. 18763a, b, c, d, e, and 18764 in the Geological Museum, Orton Hall, Ohio State University.

The ephebic stage is indicated on figures 30, 31. Although the inner ends of the primary septa are never in actual contact with each other, they now begin a definite retreat from the central area. The retreat of the cardinal septa is a little in advance of the retreat of the counters. The cardinal septa are slightly curved with the convex sides toward the cardinal septum. The counter septa are slightly zigzag rather than regularly curved or straight. Dissepiments disappear from the interseptal spaces of the cardinal septa and there remains only one in most of the interseptal spaces of the counter quadrants. In the early ephebic stage the alar pseudofossulae become most prominent, but they soon become indistinct again.

Figure 32 illustrates a section cut across the calice. The obliqueness of the calice is indicated by the more rapid retreat of the cardinal septa from the central area than is the case with the counter septa. Some of the secondary septa of the cardinal quadrants are half as long as the primaries.

Tabulae, which are not numerous, extend across the central portion of the thecarium and bend abruptly downward and terminate against marginal dissepiments in the more mature portion of the corallum. The convex sides of the marginal dissepiments are towards the calice. The epitheca is repeated by rejuvenescence at the top. These latter features can be seen in the longitudinal section, figure 33.

Remarks.—This species resembles *Zaphrentis amplexoides* (Wilmore, 1910) in possessing three (or even four) fossulae in certain stages of growth. It differs, however, from this species in the manner of development of the cardinal fossula. In the earlier stages of *Z. amplexoides* the cardinal fossula is completely enclosed by two or more septa which curve around its inner end. The fourth septa of the cardinal quadrants in the

neanic stage of *Caninia complexa* do not curve around the inner end of the cardinal septum, but fuse at their inner ends with the next older cardinal septa.

This new species is closely related to Carruther's (1910) evolutionary form of *Z. delanouei*. Externally *Caninia complexa* and any of the forms of *Z. delanouei* might be easily confused. They are much the same size and shape and the epitheca is clearly marked with longitudinal ribbing.

Carruthers says with respect to *Z. delanouei:*

> The gens of *Z. delanouei* is marked by several characters that remain unchanged (except in the case of *Z. lawtonensis*) throughout Lower Carboniferous times. These peculiarities lend an unmistakable aspect to the members of the group; they may be tabulated as follows:
>
> (1) Average size and shape.
> (2) An epitheca with clearly marked longitudinal ribbing.
> (3) Situation of the cardinal fossula on the concave side of the corallum.
> (4) Spacing and character of the tabulae, which are arched upwards and strongly depressed into the fossula.
> (5) Stout septa, thickened at the inner end.
> (6) Curvature of the septa convex to the cardinal fossula.

Caninia complexa possesses all of these general characters of the members of Carruther's *Z. delanouei* group except for character numbers 4 and 5. The tabulae are arched upwards as is the case with *Z. delanouei*, but instead of extending across the corallum in an uninterrupted fashion they give way to cysto-tabulae in the vicinity of the peripheral margin. A depression of the tabulae into the fossula is not evident, but their spacing is much the same. The septa may appear thickened at the inner ends where they meet in the earlier ontogenetic stages, but they become decidedly thinned at the ends as soon as they become free and retreat from the central area. This new species resembles *Z. enniskilleni* in this character, but differs in that *Z. enniskilleni* does not exhibit a general curvature of the septa convex to the fossula, and the fossula itself is wide and irregular in outline.

Caninia complexa differs from *Z. parallela* in possessing a cardinal septum that does not retreat from the central area any more rapidly than the rest of the major septa. The introduction of secondary septa in the late neanic stage of *C. complexa* is another notable difference between these two. They are alike, however, in that the walls of the fossula are parallel, or even slightly constricted toward the inner end.

In all of Carruther's related forms the cardinal septum retreats more rapidly from the central area than any of the other major septa. In this respect they differ from *C. complexa* in which the cardinal septum does not retreat any more rapidly than the rest of the primaries. *C. complexa* resembles *Z. disjuncta* in the development of alar pseudofossulae in the ephebic stage, but differs mainly in the number of dissepiments, rate of retreat of the cardinal septum, and the appearance of well-developed secondary septa.

There is undoubtedly a close relationship between *C. complexa* and *Z. delanouei*, neither one being very far removed from a common ancestor.

Horizon and locality.—Locality 1.

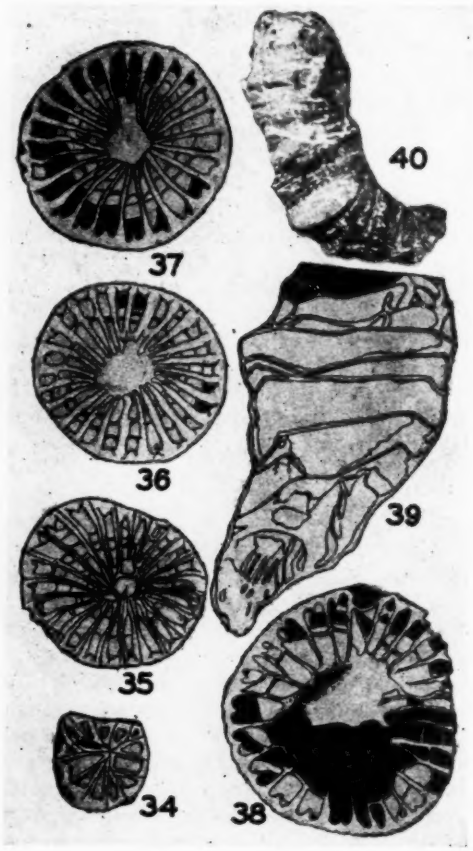
Syntypes.—Nos. 18763a, b, c, d, and e, 18764, Geological Museum, Orton Hall, Ohio State University.

CANINIA TABULATA Busch, n. sp.
Figures 34–40

External characters.—Simple corals of curved ceratoid form. Average observed size 29 mm. high, and 13.5 mm. in diameter. Expansive development of all specimens has been interrupted periodically by constrictions. Most transverse sections are circular in outline, but sometimes they are elliptical due to compression. The epitheca is well marked by both circular growth lines and inter-septal ridges. The calice features of all studied specimens are obscured by compact shale fillings. This species resembles *Amplexus hamiltoniae* externally in many respects, but internal differences are readily recognized.

Internal characters.—The neanic stage of this species is short. The only section showing this stage is shown by figure 34. The cardinal septum occupies an extremely broad fossula in comparison to its length. It is over-thickened with stereoplasm to a greater extent than the other septa. The major septa meet at the center of the thecarium. The above-mentioned figure shows 13 primary septa, four of which are majors.

The cardinal septa number two and three in the right and left quadrants respectively. Each of the counter quadrants contains two primaries. The additional septum in the left cardinal quadrant is either due to acceleration of the growth of the quadrant, or else the section was not cut at right angles to the longitudinal trend of the corallum. The latter is more than likely the case. All of the septa are thickened with a secondary deposit of stereoplasm, but not to the extent of obliterating the interseptal spaces or the quadripartite arrangement of the septa.



FIGS. *34–40—Caninia tabulata* Busch, n. sp. *34–38*, serial sections; *34*, ×4; *35–38*, ×2; *39*, longitudinal section of a syntype, ×2; *40*, lateral view of a syntype. Specimen nos. 18765a, b, c, d, e, 18766, and 18767 in the Geological Museum, Orton Hall, Ohio State University.

Dissepiments are absent and alar pseudofossulae are fairly distinct.

In the early ephebic stage (fig. 35), the cardinal septum withdraws from the center of the thecarium and occupies only half of the now much narrower fossula. The counter septum projects through the inner margin of the cardinal fossula and terminates in the open space. Secondary thickening on the septa is greatest near their places of attachment on the peripheral margin. The primary septa number 24 in the early and middle ephebic stage. This number is made up of four majors, four primaries in each cardinal, and six primaries in each counter quadrant. All of the counter primaries are radially arranged, while the cardinal primaries are pinnately arranged to form the fossula. Secondary septa project as low ridges between the primaries of the cardinal quadrants only. Dissepiments vary from one to five in number, being much more abundant in the cardinal than in the counter quadrants.

The section shown in figure 36 was cut just below a tabula. The slight retreat of the septa from the central area and the lack of fusion of their inner ends are amplexoid characters. All of the septa are radially arranged. Dissepiments are fewer than in the previous section, there being from one to three in each interseptal space. The inner end of the cardinal septum is joined to the two septa on either side by dissepiments. Secondary septa are very poorly indicated in all quadrants. The primaries still number 24.

The section shown in figure 37 was cut just above a tabula, hence the inner ends of the septa appear somewhat fused again. The cardinal septum projects inward for half the length of the fossula and tapers toward the center. The central area is approximately circular in outline and opens into the cardinal fossula. Dissepiments vary from one to two, and secondary septa are easily recognized.

Figure 38 is a section of the same specimen cut just above the floor of the calice. The cardinal septum has become completely aborted, thus leaving a true fossula. The outer wall becomes invaginated into this fossula and resembles a broad dissepiment with the convex side inward. This is prob-

ably an individual variation. The length of the primary septa varies from one-third to one-fourth the diameter of the corallum. They have increased in number up to 27. A few dissepiments are still present. Secondary septa are a trifle longer than in the previous section.

Well-developed, flat tabulae are the most pronounced feature in the longitudinal section, figure 39. The inter-tabular spaces in the youthful portion of the corallum are almost filled with other endothecal structures such as septa. In the ephebic portion of the corallum the tabulae extend horizontally most of the distance across the thecarium and then bend abruptly toward the apical end and merge with the outer wall. There are six prominent tabulae in the ephebic portion of this section. Toward the calice the tabulae appear to give way laterally to dissepimental structures. The tabulae in this section are encrusted on both sides with crystallized calcite.

Remarks.—The most characteristic features of this species are: quadripartite septal arrangement in the neanic stage; radial septal arrangement in the ephebic stage; equal development of the cardinal and counter quadrants in the ephebic stage; progressive retreat of the cardinal septum; well-developed cardinal fossula; and well-developed tabulae.

The excellent development of the cardinal fossula and the very slow retreat of the septa from the center of the corallum are characters which alone will serve to distinguish *C. tabulata* and *Amplexus hamiltoniae.*

Horizon and locality.—Locality 3.

Syntypes.—Nos. 18765a, b, c, d, and e, 18766, and 18767, Geological Museum, Orton Hall, Ohio State University.

Family LACCOPHYLLIDAE Grabau
Genus BARRANDEOPHYLLUM Počta

Genotype.—Barrandeophyllum perplexum POČTA, *1900,* System Sil. du Centre de la Bohême, vol. 8, tome 2, pp. 190 et seq.

Počta (1902) established this genus on a single specimen of a small, simple coral from the Lower Devonian of Bohemia. Species referred to this genus range from small to moderate in size and may be curved. The epitheca shows septal grooves which are quite feeble on the outside of the moderately deep calice. Počta's type species has 26 primary and 26 secondary septa. The primaries unite at their inner ends at a fourth of the height above the apex to form a large central tube which expands as it approaches the base of the calice. Počta stresses the absence of secondary stereoplasm in this genus as the chief difference from the genus *Alleynia.* The writer agrees with Grabau in questioning the feasibility of establishing two different genera on this feature alone. The Hamilton forms of *Barrandeophyllum* all show marked secondary stereoplasmic thickening, but are quite similar when it comes to the structural relations within the thecarium. The inner tube of *Alleynia* is almost cylindrical whereas that of *Barrandeophyllum* widens rapidly. This is undoubtedly a better basis for generic distinction.

BARRANDEOPHYLLUM REIMANNI
Busch, n. sp.
Figures 41–49

External characters.—Corallum moderately and sometimes irregularly curved trochoid, rapidly expanding, and circular to oval in cross section (fig. 48). Average observed size 27 mm. high, and 16.5 mm. in diameter. Numerous growth constrictions and expansions, crowded growth lines, together with prominent interseptal ridges, characterize well-preserved specimens. All observed calices are either filled or broken.

Internal characters.—In the neanic stage of this species the septa reach the center. In figure 41, the axial septum is the only distinguishable septum of the four majors. The inner ends of both the cardinal and counter septa are joined to form this axial septum. All of the septa are heavily coated with a secondary deposit of stereoplasm. This deposit is so thick in some places that the interseptal spaces are completely filled. Most cross sections are circular in outline. This section is quite distorted in outline because it was cut near the apical end where the specimen was attached by means of a rootlet. The septa shown in figure 42 are so much thickened as to be distinguished with difficulty. There is a slight twisting of their inner ends where they meet in the center. Neither cardinal nor alar pseudofossulae are developed in this stage. There is one dis-

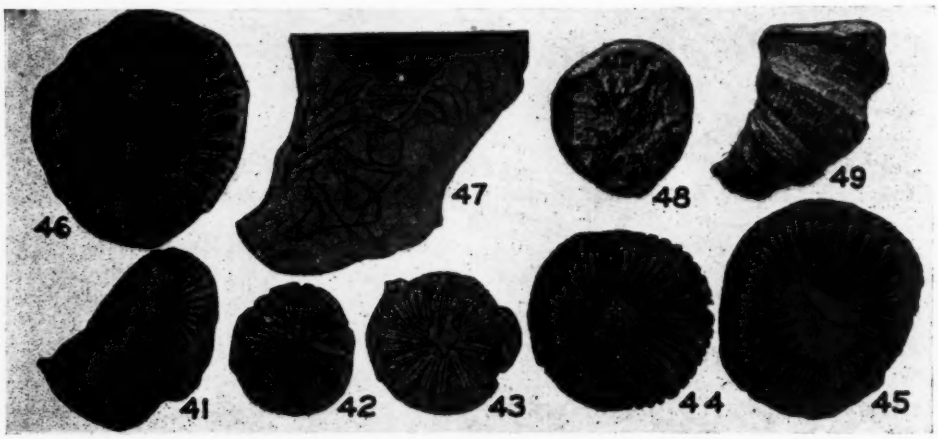
sepiment in each interseptal space as far as can be determined.

The septa gradually retreat from the central area of the corallum in the ephebic stage, but nevertheless remain united at their extremities by stereoplasm to form a prominent central tube. This tube is irregularly elongate in cross section due to the varying lengths of the septa, as shown in figure 43. It is open at the cardinal end, where the cardinal septum freely projects into the aperture. It is continued into the openings on both sides of the cardinal septum. The cardinal septum gradually shortens and is connected by dissepiments, with the two adjoining septa, which approach the main portion of the central tube, figure 44. The septa are all so strongly thickened by stereoplasm that the interseptal loculi are isosceles triangles, linear, elongate-oval, or even tear-drop in outline. There are two thick dissepiments in the majority of the interseptal areas. It is difficult to positively locate the alar septa, but it appears that there are five primary septa in each of the cardinal and counter quadrants. Secondary septa do not appear in the section, but their position is indicated by the costal grooves on the surface.

In figure 45, a notable ontogenetic change may be noted. The ends of the counter septa are no longer fused, but have thinned considerably and as a result are left gapping. The only remnants of the tube are to be seen along the ends of some of the cardinal septa. The cardinal septum has retreated until it is now one-half the length of the septa on either side. There is an accelerated secondary septum between the cardinal septum and the youngest primary septum of the right cardinal quadrant. This odd septum cannot be distinguished from the primaries in the cross section of the filled calice (fig. 46). The number of primaries in a mature corallum is 26, and this accelerated secondary is probably an individual variation. The positions of secondary septa are clearly indicated by pseudo-costal grooves opposite the cardinal quadrants, but they are not so clearly shown opposite the counter quadrants.

Figure 46 was cut across the filled calice of the specimen. The counter septa are about twice as long as the cardinal septa. A few dissepiments are still noticeable in the counter quadrants. Near the marginal extremities of the calice the secondary septa of some specimens have almost an equal development with the primaries.

The longitudinal section of a different specimen (fig. 47) shows broadly arched tabulae with the convex sides toward the calice. There is a semblance of a central tube in this profile which is well marked off just



FIGS. *41–49—Barrandeophyllum reimanni* Busch, n. sp. *41–46*, serial sections; *41*, ×4; *42–46*, ×2; *47*, longitudinal section of a syntype, ×2; *48*, filled calice view of a syntype; *49*, lateral view of the same specimen. Specimen nos. 18768a, b, c, d, e, f, 18769, and 18770 in the Geological Museum, Orton Hall, Ohio State University.

below the calice but not so clearly defined farther down. The right side of this section (the side of greatest convexity of the corallum) is blurred because the section splits one of the over-thickened septa.

Remarks.—*Barrandeophyllum reimanni* resembles *B. disjunctum* Grabau (1928, pp. 93–95) in several respects. They differ, however, in that indications of secondary (tertiary of Grabau) septa are lacking in *B. disjunctum*, whereas they do appear in the calice of *B. reimanni*.

The wall of the inner tube of *B. reimanni* is not as distinct, nor does it pull away from the septal ends in the same manner, as is the case with *B. disjunctum*. It also fails to open on the dorsal or counter side of *B. reimanni* as in *B. disjunctum*.

The essential internal characters of this species may be summed up as follows: extremely heavy secondary deposit of stereoplasm on the septa; appearance of an inner tube in the ephebic stage which is open on the cardinal side and projects into the two spaces on either side of the cardinal septum, tube is slightly thickened; withdrawal of tube from counter septal ends toward the cardinal quadrants; septa retreat more rapidly from the central area than the corallum expands.

Horizon and locality.—Localities 1 and 2. Apparently this genus has not been recognized before in the Hamilton.

Syntypes.—Nos. 18768a, b, c, d, e, and f, 18769, and 18770, Geological Museum, Orton Hall, Ohio State University.

Barrandeophyllum simplex
Busch, n. sp.
Figures 50–55

External characters.—Corallum of moderate size, curved trochoid, rapidly enlarging. All sections are essentially circular with an average diameter of 14.5 mm. across the calice. The mature portion is not slightly flattened as is the case with most species of *Barrandeophyllum*. Interseptal ridges are well developed and show normal pinnate arrangement of the simple tetraseptate corals.

Internal characters.—In the neanic stage the four major septa, which meet in the center, are difficult to distinguish. This very short stage is typified by figure 50. This section was not cut at right angles to the longitudinal trend of the corallum, hence the cardinal septa appear over-elongated. The positions of the alar pseudofossulae are indicated by the pinnate arrangement of the counter septa. There are approximately 20 septa all of which are greatly secondarily thickened. Dissepiments number from one to two.

The initial phase of the ephebic stage is characterized by a pulling away of the inner ends of the septa from the central area. These inner ends are united and there is a distinct layer of sclerenchyma which forms an inner tube. The primary septa in the early mature stage number approximately 22, with four in each cardinal, and five in each counter quadrant. The four majors bring the total up to 22. Extreme secondary thickening shown in figure 52, almost obliterates the interseptal spaces, as well as the septa themselves. The inner tube assumes a pyriform outline with the pointed end indicating the position of the cardinal septum. A most notable feature of the middle ephebic stage is a gradual pulling away of the sclerenchymal tube from the inner ends of the counter septa. This recession takes place concomitantly with the projection, on the opposite side, of the tube into the spaces on both sides of the cardinal septum (fig. 53). The maximum number of primary septa has been attained, namely 26. Secondary thickening is thin on the broad bases of the septa and becomes thicker along the inner ends. Interseptal spaces are long and narrow and may or may not contain dissepiments. Figure 54 illustrates a still later stage where the inner tube has retreated from all but seven of the cardinal septa. The primary septa (exclusive of thickening) have retreated until they are now only about one-fourth the diameter of the corallum in length. In this same section secondary septa are just beginning to appear.

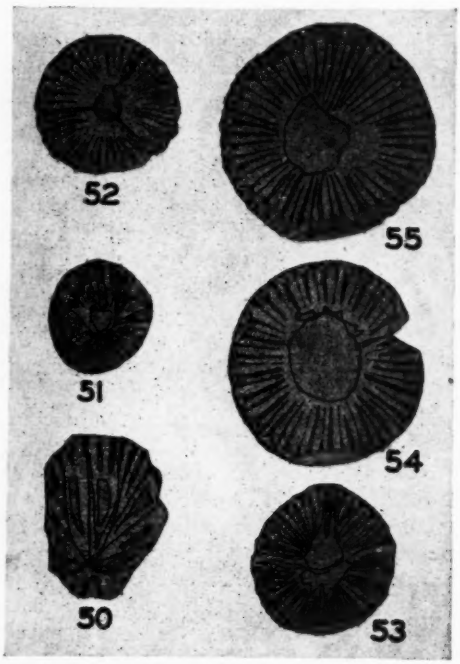
The septa no longer retreat from the inner area once the inner tube has disappeared. In figure 55, the corallum has expanded and the inner area has maintained the same diameter as in the preceding section.

Inasmuch as this is the only specimen found it was not possible to make a longitudinal section as well as cross sections.

Judging from other species of *Barrandeophyllum* it is likely that several tabulae project across the thecarium.

Remarks.—This species differs externally from *B. reimanni* in the following respects: Epitheca (of *B. simplex*) is much less wrinkled; more conical and less curved; interseptal ridges are more pronounced; tetrameral arrangement of the septa is more distinct.

Internal characters for *B. simplex* are: Septal retreat from the inner area begins much earlier than in *B. reimanni;* inner tube is distinctly secondarily thickened; inner area remains almost cylindrical after disappearance of inner tube; cardinal septum does not project to the center of the tube immediately after the latter becomes open at the cardinal end.



FIGS. *50–55—Barrandeophyllum simplex* Busch, n. sp. Serial sections; *50*, ×6; *51–55*, ×2. Specimen nos. 18771a, b, c, d, e, and f in the Geological Museum, Orton Hall, Ohio State University.

Horizon and locality.—Locality 1.

Holotype.—Nos. 18771a, b, c, d, e, and f, Geological Museum, Orton Hall, Ohio State University.

Genus ALLEYNIA Počta

Nicholsonia POČTA, *1902*, Anthozaires et Alcyonaires, in Barrande, System Sil. du Centre de la Bohème, vol. 8, t. 2, pp. 184 et seq.; ——, *1902*, idem., vol. 8, t. 2, pls. 68, 108, 110, 112.

Genotype.—Petraia bohemica (BARRANDE).

All of the Silurian and Devonian species are as a rule minute, conical, or turbinate. To quote Grabau (1928, pp. 84–85):

> They contract laterally towards the base and sometimes are a little curved. Epitheca well-developed except where destroyed before or during fossilization. Septal grooves well-developed and showing normal pinnate arrangement of the simple tetraseptate corals. The cardinal septum is sometimes shown on the exterior of the coral, but this is not common, for in most cases the septa are radial. Although the thin border of the calyx of most of the specimens is broken, it is nevertheless possible to ascertain that the depth of the calyx was as much as two-thirds the height of the total corallum, the septa forming low ridges on its inner margin. The mass of the endothecal structures is restricted to the lower third of the corallum.
>
> The number of septa varies from 18 to 24 though sometimes the number is increased to 40 or 48. They are always of two different sizes. They are generally much thickened by secondary stereoplasm, which also thickens the epithecal wall. In the center the septa unite to form a median cylindrical tube, which in all cases is hollow and indeed is to be regarded as a true phyllotheca. It is always joined to the wall of the corallum by supporting beams of sclerenchyma. The empty spaces or lacunae surround this central tube. Sometimes the basal portion, however, as well as that within the tube, is entirely filled by stereoplasm. Within the central tube which Počta wrongly denominates a pseudo-columella, the space is divided by many horizontal tabulae.

The Hamilton forms are slightly to irregularly curved and the expansive development is not nearly so rapid as is the case with Počta's forms. Although the calices of most of the specimens studied are broken away so that the septa cannot be determined, it is very unlikely they were anywhere near two-thirds the height of the corallum. The quoted statement that "the septa are always of two sizes," is misleading. Počta figures no more than one section for any particular specimen and these are always in portions which represent the neanic (*Alleynia bohemica*) or early ephebic (*Alleynia perfecta*) stages of the ontogeny. This apparent difference in septal sizes is not noticeable in sections cut across more mature portions of any particular specimen.

The number of horizontal tabulae in the central tube of both of the genera *Alleynia* and *Barrandeophyllum* is noticeably less than Počta's Bohemian forms.

The differences cited above between the Hamilton forms and the described species of *Alleynia* are not considered sufficiently important to warrant separation into a distinct genus.

ALLEYNIA AMERICANA Busch, n. sp.
Figures 56–63

External characters.—The corallum is curved ceratoid and many specimens show an irregularly varying direction of growth. Constrictions followed by rapid expansive development are common features. Average observed size 22 mm. high, and 11.5 mm. in diameter. Interseptal ridges are fair to poorly developed; when sufficiently well-developed they show normal pinnate arrangement. Fine growth lines are fair to well-preserved. The apical end is frequently missing, and the calice is either filled with rock material or entirely broken away. It is therefore practically impossible to study the septal arrangement from an uncut specimen.

Internal characters.—In the early neanic stage the primary septa unite in the center to form a median cylindrical tube. This tube is hollow and is a true phyllotheca as shown in figure 56. The cardinal septum has the same length as the rest of the primaries, but it is not thickened to the same extent as the others. The cardinal and alar pseudofossulae are equally conspicuous. The primary septa are 12 in number, and, with the exception of the third septum in both of the counter quadrants, are radially arranged. Several of the lacunae are divided by one or two dissepiments.

The phyllotheca opens early in the neanic stage opposite the cardinal septum and the primary septa are united by their inner ends to form a horseshoe-shaped tube. The cardinal septum retreats rapidly until, as shown in figure 57, it is only one-fourth the length of the fossula. This section shows clearly the characters of the genus *Hapsiphyllum*. The inner ends of two of the septa on the right side of the fossular gap have pulled away, but on the left side they are still fused.

The orientation of the section shown in figure 58 is problematical. The septa are segregated and pinnately arranged in clusters numbering from two to six in a cluster. There are still semblances of the elongated inner area of the preceding section, but there is a tendency toward the breaking up of this horseshoe-shaped opening. The major septa cannot be distinguished from the other primaries. Stereoplasmic thickening is moderate to great on the septa and inner side of the epithecal wall. A few dissepiments are present, but there is no indication of secondary septa.

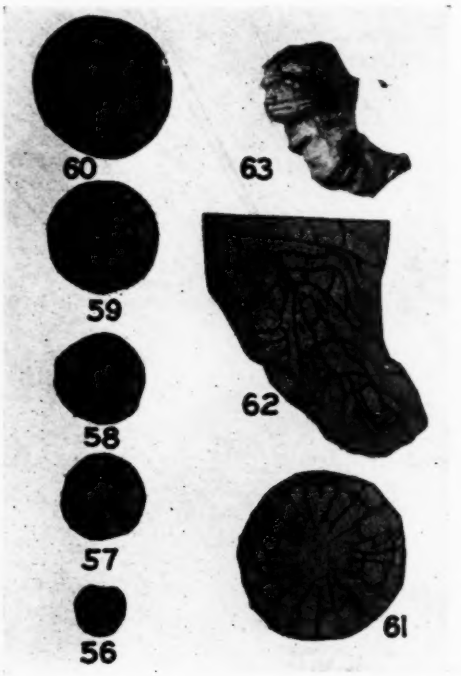
The return of the cardinal septum to the central portion of the corallum, after it has once retreated to the peripheral margin, is a rather unusual feature of this species (see fig. 59). It extends the entire length of the cardinal fossula. The corallum continues to expand and the septa to increase in number. The primary septa number 18, the two most youthful ones being quite short and forming a portion of the walls of the cardinal fossula. Many of the septa are zigzag rather than straight. They are pulling away from the inner tube which appears to be poorly supported. Alar pseudo-fossulae are indistinct and dissepiments are few or absent.

The ephebic stage is indicated by the amplexoid tendency of the septa to withdraw from the central area. The septa are for the most part radially arranged. The cardinal septum shown in figure 60 has a length one-fourth the diameter of the section. The walls of the fossula, which are formed by the septa on either side of the cardinal septum, are essentially parallel for two-thirds of their length and then converge toward the center of the corallum.

There are 20 primary septa; four majors, three in each of the cardinal quadrants, and five in each of the counter quadrants. The stereoplasmic thickening of the septa has decreased considerably so that the interseptal spaces are quite large. Alar pseudofossulae are indistinct. Secondary septa are absent.

The septa, shown in figure 61, have not retreated much more from the central area than is shown in the preceding section. The expansive development of the corallum has continued, however. The third septa of the cardinal quadrants are no longer fused at their inner ends with the second septa. The cardinal septum has retreated to one-

half the length of the fossula. Instead of being attached to the peripheral margin of the fossula, it has pulled away and is now attached to a long dissepiment which joins the two septa on either side of the cardinal septum near their points of attachment. The septal arrangement is decidedly radial. Dissepiments vary from one to two for each interseptal space. There is no indication of secondary septa.



FIGS. *56–63—Alleynia americana* Busch, n. sp. *56–61*, serial sections ×2; *62*, longitudinal section of a syntype, ×2; *63*, lateral view of another syntype. Specimen nos. 18772a, b, c, d, e, f, 18773 and 18774 in the Geological Museum, Orton Hall, Ohio State University.

The longitudinal section, shown in figure *62*, shows the development of the wide-spaced tabulae which extend for most of the distance across the corallum and then bend sharply toward the apical end. The central tube is shown to exist in the lower three-fourths of the section. Its absence in the upper one-fourth of the section is equally apparent.

Remarks.—This species differs in several respects from described species of the genus. The clustered arrangement of the septa at one place in the neanic stage, the absence of secondary septa (tertiary of Grabau), and the long, cylindro-conical external form are its most distinctive features.

A. americana, n. sp., most closely resembles *A. perfecta* Počta. In both forms the septa in the neanic stage are united toward the center and the cardinal septum disappears and is replaced by a fossula or vacant space. The result is a horseshoe-shaped tube which extends from the center of the corallum to the peripheral margin. Grabau states that such a tube normally precedes the formation of the closed inner wall and is characteristic of such genera as *Craspedophyllum* and *Hapsiphyllum*. The reverse order of events is characteristic of *A. perfecta* and *A. americana*. Ordinarily the more primitive quadripartite arrangement of the septa appears in the neanic stage, and this is followed by a change over to a radial arrangement in the ephebic stage. These two species, however, show degenerate characteristics in that the septa are first radially and then pinnately arranged. *A. americana* is distinct from *A. perfecta* in that it again assumes a radial septal arrangement as the septa become amplexoid in the late ephebic stage. It is quite possible, however, that *A. perfecta* would also revert to a similar septal arrangement if more mature sections of this specimen were available for study.

Horizon and locality.—Locality 3.

Syntypes.—Nos. 18772a, b, c, d, e, and f, 18773, 18774, and 18775, Geological Museum, Orton Hall, Ohio State University.

Family HAPSIPHYLLIDAE Grabau
Genus HAPSIPHYLLUM Simpson

Hapsiphyllum SIMPSON, *1900*, New York State Mus. Bull. 39, p. 203, fig. 10. GRABAU, *1928*, Pal. Sinica, B, 2 (2) pp. 118–120, fig. 21.

Genotype.—Zaphrentis calcariformis HALL, *1882*, New York State Mus. Nat. Hist. Ann. Rept. 35, p. 33 (advance sheets); Indiana Dept. Geol. and Nat. Hist. Ann. Rept. 12, p. 293, pl. 21, figs. 10, 11.

Original description.—Corallum small, simple, conical or horn-shaped; calyx circular, comparatively deep, with thin margins; biareal. The outer area is bounded by the external epitheca; the inner area by a subvertical wall of horseshoe-shape, open on the side of the septal fovea. Two of the larger septa connect with this wall in such a manner as to be apparently a continuation of it, and form a very distinct pyriform septal fovea;

septa alternating in size, the smaller ones continuing for a short distance into the cavity of the corallum, there coalescing with the larger ones, which continue to the inner wall, with which they coalesce, and in which they terminate. Tabulae and dissepiments are present.

The wall of the inner area, connecting with two of the septa and bounding a portion of the septal fovea, is similar to that of *Agonophyllum*, but that genus differs from this in several respects, principally in having carinations on the sides of the septa.

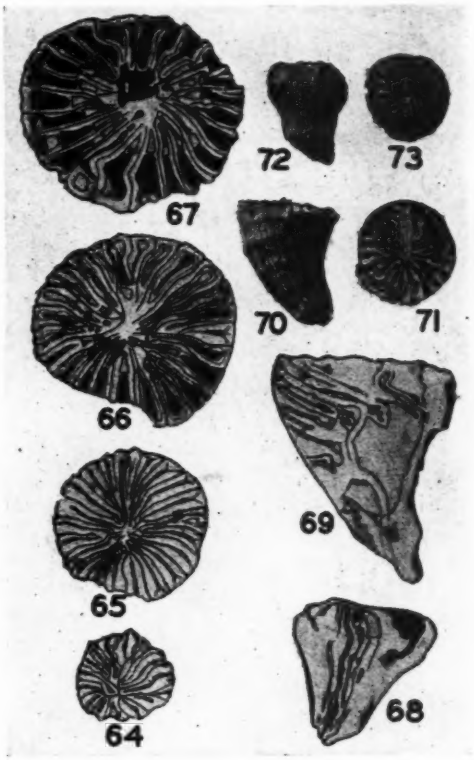
Grabau feels that this genus is more closely allied with the Streptelasmidae than with the Zaphrentidae family. The presence of a fossula is the only important feature this genus has in common with the Zaphrentidae. Grabau points out the acceleration of the counter quadrants, and the septa united into a horseshoe-shaped inner wall, by the septal ends themselves, as the chief characters of the genus *Hapsiphyllum*. He considers *Zaphrentis delanouei* Edwards & Haime as a typical example.

Hapsiphyllum bifurcatum
Busch, n. sp.
Figures 64–73

External characters.—Corallum curved trochoid and expands at a variable rate in the young, the latter of which gives the individual an irregular lower portion. Maximum observed size 24 mm. high, and 15 mm. in diameter; average observed size 15.5 mm. high, and 10.5 mm. in diameter.

The calice in every specimen is quite shallow and the calicular edge is usually rounded on weathered specimens. The cardinal fossula is well exposed on most specimens and is neither on the concave nor convex side of the corallum, but varies in its position between these two sides. Septal grooves are very pronounced and in most specimens the interseptal ridges bifurcate in the adult portion of the corallum. The quadripartite arrangement of the septa is frequently seen in the calice. The position of the principal septa is evident from the arrangement of the septal grooves.

Internal characters.—In the early neanic stage the cardinal septum fails to reach the union point of the other three majors as shown in figure 64. This septum is quite zigzag and greatly over-thickened with a secondary deposit of stereoplasm to much the same extent as the rest of the primaries. It occupies two-thirds the length of a relatively large fossula formed by the convergence of the two primaries on either side. There are 18 primary septa in this section, four of which are majors, three in each cardinal quadrant, and four in each counter quadrant. The over-thickened septa are pinnately arranged in four groups and curve



Figs. *64–73*—*Hapsiphyllum bifurcatum* Busch, n. sp. *64–67*, serial sections, ×2; *68*, *69*, longitudinal sections of two syntypes, ×2; *70*, lateral view of a syntype; *71*, calice view of the same specimen; *72*, lateral view of another syntype; *73*, calice view of the same specimen showing the horseshoe-shaped fossula. Specimen nos. 18776a, b, c, d, 18777, 18778, 18779, and 18780, in the Geological Museum, Orton Hall, Ohio State University.

quite irregularly. Alar pseudofossulae are quite distinct and dissepiments are entirely absent.

A much later neanic stage is indicated in figure 65, where the cardinal septum has retreated to one-half the length of the fos-

sula. The fossula is formed by the youngest pair of cardinal septa as far inward as the place where their inner ends either fuse with or rest against the next older septa. These two latter septa extend toward the center of the corallum, and in turn are fused at their inner ends with the next older septa. The inner end of the fossula is left gapping as the other septa have retreated a short distance from the center. There are 23 curved, pinnately arranged, primary septa in this section. The curvature of the septa is with a dominant convexity toward the cardinal septum. There are four primaries in each of the cardinal quadrants, five in the left counter, and six in the right counter quadrants.

In the early ephebic stage the horseshoe-shaped cardinal fossula appears (fig. 66). The prominent primaries forming the fossular wall are parallel for most of their length, but diverge and then converge rapidly near their place of attachment to the outer wall. The septa are still wavy and the symmetry is dominantly pinnate. This specimen attains its maximum number of 24 primary septa in early maturity, but individuals vary in this respect. Other specimens in my collection display as high as 29 primaries in maturity. Dissepiments now appear and vary from two to three per interseptal space. Invaginations of the outer wall producing the effect of secondary septa make their appearance.

A more advanced stage is shown in figure 67, where the septal ends produce a wavy horseshoe-shaped fossula due to the slight variation in lengths. The contrast between the size of the cardinal and counter quadrants is well shown, with the latter being the larger of the two sets. This section was cut just below the calice, and shows much of the same septal characters as are seen in an external calice view.

Tabulae are present, as seen in the longitudinal sections (figs. 68, 69), and do not cross the space of the cardinal fossula. In figure 68, the tabulae, which are greatly over-thickened, appear to cross the open space, whereas in figure 69, they mark the upper and lower limits of the fossula. Longitudinal sections cut through any plane other than that of the cardinal fossula do not show any open space.

Remarks.—This species can be identified almost solely on external characters. The rounding of the calicular edge and the shallowness of the calice, together with the bifurcation of the interseptal ridges on the adult portion of the caliculum, are sufficiently characteristic features of this species to separate it from other described species.

Dominant internal characters are as follows: failure of the cardinal septum to unite with the other major septa in any developmental stage; twisting and pinnate arrangement of primary septa until middle ephebic stage; invaginations of the outer wall into the interseptal spaces; open space appears in the longitudinal sections cut parallel to the plane of the fossula; absence of secondary septa.

Horizon and locality.—Locality 3.

Syntypes.—Nos. 18776a, b, c, d, 18777, 18778, 18779, and 18780. Geological Museum, Orton Hall, Ohio State University.

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SYMBOLS FOR CRINOID PARTS

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ABSTRACT—Designation of structural elements of crinoids in figures and published descriptions is comnonly made by means of abbreviations that were mainly originated by Bather. Widespread usage establishes the general acceptability of the symbols, but there are difficulties, which this paper calls to attention and seeks to remove. Revision of some symbols is proposed, chiefly to avoid ambiguity in use of the capital letter I and the Roman numeral I, a standard method of pluralization of symbols is indicated, and omission of symbols for structural elements that are not commonly mentioned in crinoid descriptions is suggested.

INTRODUCTION

IT IS NATURAL that extensive use of classificatory morphologic designations in any biologic group should lead to adoption of the most convenient practicable means of referring to them in abbreviated form. Such shorthand saves time in writing, economizes space in labeling parts of a diagram or in printing of text descriptions, and it has the advantage of setting up a distinction between the symbols for technical terms and ordinary words. This is especially true if the symbols are printed in italics, which is a growing custom of editorial treatment in recently published papers on crinoids. Use of these symbols has the disadvantage that one must know what they mean in order to understand them, but this is obviated by familiarity on the part of all paleontologists who are interested in this group of fossils with the commonly used abbreviations for morphologic elements. For benefit of the uninitiated student there are textbooks and numerous papers that give concise explanations of symbols for crinoid parts. The literature on crinoids extensively employs these symbols.

There is general agreement among authors in choice of abbreviations for crinoid parts as shown in drawings and treated in detailed descriptions. This agreement applies especially to elements of the dorsal cup and arms and it incorporates abandonment of antiquated terminology such as underbasals (for infrabasals), subradials (for basals), costals (for primibrachials), distichals (for secundibrachials), azygos or azygous plates (for first anal and radianal), and others. Nevertheless, discordance in usage of symbols is seen. Publication of internally conflicting and even erroneous plate symbols for crinoids in textbooks of invertebrate paleontology (23, 30) is not helpful, to say the least. Students are likely to get a wrong start and one who is not a specialist in study of crinoids may be misguided by reference to these works. A review of the subject is worth while because study of the system of abbreviations indicates that revision of some features offers helpful improvements. The present paper is an outgrowth of work that we have been requested to undertake for a chapter on crinoids in the projected new edition of North American Index Fossils by Grabau, Shimer and Shrock.

USAGE OF SYMBOLS FOR CRINOID PARTS

Most descriptive papers on fossil crinoids published before 1900, and many bearing more recent dates (4, 6, 7, 10, 12, 22, 23, 31, 34, 35) make little or no use of symbols. Names for parts are written in full.

First to make extended use of letter symbols for designation of elements of crinoid skeletons were Wachsmuth and Springer (31) in diagrams published to accompany their Revision of the Palaeocrinoidea (1879–1886), but they did not employ these abbreviations in text discussion or description of these fossils. Moreover, symbols were not used by these authors (32) in their monograph on the Crinoidea Camerata (1897), except in diagrams showing the structure of representative genera. Bather (1) in 1893 adopted some of the symbols that had been published by Wachsmuth and Springer, but he mostly preferred capitals instead of lower case letters, and he introduced new abbreviations for several mor-

phologic elements. These symbols were not only used by Bather on drawings but were incorporated in the text. A summary of the designations for some of the more important crinoid parts, as given by Wachsmuth and Springer and by Bather, is presented in the following tabulation.

Although the citations indicated in the mentioned table are by no means complete, attention is called to the fact that several papers, including important monographs, may be grouped under reference to one author. Thus, the number of references following a given symbol does not reflect very closely or accurately the usage of the symbol. Where an author has occasion to refer to a crinoid part only in the singular or plural number, the symbol is introduced in the tabulation as actually employed. Otherwise, it is obvious that there would be many more entries.

Partial list of symbols used by Wachsmuth and Springer (31, 32) 1879–1897, and Bather (1, 2), 1893–1900

Crinoid part	W. & S. 1879	W. & S. 1881	W. & S. 1885	Bather 1893	W. & S. 1897	Bather 1900
Infrabasal	u	u	u	IB	ib	IB
Basal	b	b	b	B	b	B
Radial	r, r^1	r, r^1	r	R	R	R
Primibrachial	r^1, br	r^1	br	IBr	I	IBr
Secundibrachial	r^2, a	r^2	—	IIBr	II	IIBr
Interradial	i	i	i	IR	ir	IR
Interbrachial	d	d	d	ibr	ibr	iBR
First anal	an	x	x	x	x	x
Radianal	an	—	a, az	R′	—	RA

Additional symbols used by Wachsmuth and Springer include the following: a, A, AO, AT, C, c, cd, cr, dd, e, FR, fa, fp, G, H, h, I, IA, id, IX, o, p, pd, rd, RP, t, xd, xo, and xr.

It is noteworthy that all of the names of crinoid parts in the foregoing table are substantive adjectives, as indicated by the -al endings, the word "plate" being understood. Use by Bather and others of primibrach, (instead of primibrachial), secundibrach, interambulac, and similar terms is inconsistent, and although defensible as a colloquialism or abbreviation, it is deemed by us to be undesirable.

Papers that have been published within the last thirty years, that is, since 1910, include many works on crinoids that make use of symbols to indicate different categories of plates and to specify individual plates or ossicles. This adoption of symbols in description of crinoids is not confined to American and British writing but is found in German, Dutch, French, Italian, Russian, and Spanish papers. A definite tendency to follow the characters introduced by Bather is observed. There are variations that seem partly to reflect inherent difficulties in the system and partly to show lack of consideration on some points. The following lists indicate symbols for the more important crinoid elements that have been used in recent years, index numbers referring to the end bibliography.

Symbols for crinoid parts used in representative papers, 1910–1941

Plate name	Symbol	References
Infrabasal	IB	3, 10, 18, 19, 21, 22, 23, 28, 36
	ib	23
	IBB	30
	JB	11, 17
Infrabasals	IB	7, 9, 22
	IBB	3, 5, 10, 12, 15, 16, 17, 18, 19, 20, 21, 23, 26, 28, 33, 36, 37
	JB	33
	JBB	11, 17, 33
Basal	B	3, 5, 9, 10, 11, 12, 18, 19, 21, 22, 23, 25, 26, 28, 33, 36
	b	23, 27
	BB	30
Basals	B	7, 9, 22
	BB	3, 5, 10, 12, 15, 16, 17, 18, 19, 21, 23, 26, 28, 33, 36, 37
Radial	R	3, 9, 10, 12, 15, 17, 18, 19, 20, 21, 22, 23, 25, 27, 28, 33, 36
	RR	30
	C1	11

Symbols for crinoid parts used in representative papers, 1910–1941—Continued

Plate name	Symbol	References
Radials	R	7, 9, 22
	RR	3, 5, 10, 12, 16, 17, 18, 19, 21, 23, 25, 26, 28, 33, 37
Inferradial	Ri	3, 12, 21, 22, 25
Superradial	Rs	3, 12, 21, 22, 25
(Radius)	R	7
Brachial	Br	16, 18, 19, 21, 22, 23, 33
	br	23
Brachials	Br	3, 5, 7, 15, 19, 23, 26
Primibrachial	IBr	5, 10, 12, 18, 19, 23, 26, 28, 30, 33, 36
	r^2, r^3	21, 23
	IB	27
	C2, C3	11
Primibrachials	IBr	3, 5, 7, 12, 16, 17, 18, 19, 21, 23, 26, 28, 33
	IBrBr	17
	Ibr	16
	C	22
	c′, c″, c‴	9
Secundi-brachial	IIBr	10, 18, 19, 21, 23, 26, 28, 30, 36
	IIB	27, 36
	D	22
	Dc	11
Secundi-brachials	IIBr	5, 7, 12, 16, 17, 18, 19, 21, 23, 26, 28, 36
	IIBrBr	17
Axillaries	Ax	19
Primaxil	IAx	3, 10, 12, 19, 21, 23, 36
	IBr_2	5
	aIAx	17
Secundaxil	IIAx	10, 19, 23, 26
Interradial	IR	8, 10, 23
	ir	30
	JR	11, 17, 33
Interradials	IR	9, 10, 23
(Interradius)	IR	7, 12
	IBr	22
Interbrachial	iBr	5, 17, 23, 33, 36
	ibr	23
	ir	23

Symbols for crinoid parts used in representative papers, 1910–1941—Continued

Plate name	Symbol	References
Interbrachials	iBr	7, 15, 16, 23, 26, 36
	IBr	22
	iIBr	21
Intersecundi-brachial	iIIBr	23
Intersecundi-brachials	iIIBr	7, 15, 16, 23, 26
	ID	23
First anal	anal X	12, 17, 21, 26, 36
	anal x	5, 7, 12, 19, 23, 28, 33
	X	12, 16, 22, 23, 25
	x	3, 7, 10, 12, 18, 19, 21, 23, 27, 32, 33
	A	11, 30
	Ac1	11
	A1	17
	a	23
	IRA	9, 23
Second anal (in series)	Ac_2	11
	SX	23
Right tube plate	RT	12
	rt	12, 18, 19, 28, 33
	a′	23
	A_2	17
	a^2	27
	anal 2	28
	Pa	11
Left tube plate	lt	18, 19, 33
	a″	23
	a^3	27
	mt	7
Radianal	a	32
	RA	3, 5, 7, 9, 10, 12, 16, 17, 18, 19, 21, 22, 23, 25, 27, 28, 30, 33, 36
	Ra	26
	ra	12, 23
	R′	21
	Sa	11
Ambulacrals	Amb	7, 23, 33
Interambula-crals	iAmb	7, 23
Oral	O	18, 20, 22, 33
Orals	O	7, 23
	OO	17

Synonymy and duplication of symbols is seen in the tables that are given, but desirability of simplification and standardization of abbreviations for crinoid parts is even better shown by an alphabetically arranged list of symbols that incorporates various used ways of defining anterior, posterior, right and left but not the numbers for designation of a particular plate in a series. Most paleontologists will agree that a large number of these symbols are not useful in descriptive writing on crinoids. The following list separates characters having initial Roman numerals from those beginning with the capital letter I, although in printed form they are indistinguishable.

Alphabetically arranged list of symbols for crinoid parts

A—first anal plate; anterior; arms
Ac_1—first anal plate

Ac_2—second anal plate
Ac_3—third anal plate
A_2—second anal plate
a—anterior; first anal plate; radianal
a′—right tube plate
a″—left tube plate
a_2—right tube plate
a_3—left tube plate
Amb—ambulacral; ambulacrals
anal 2—right tube plate
anal X—first anal plate
anal x—first anal plate
ANT—anterior
ant—anterior
Ax—axillary; axillaries
aIAx—primaxil
B—basal
B_1—left posterior basal
B_2—left anterior basal
B_3—right anterior basal
B_4—right posterior basal
B_5—posterior basal
b—basal
BB—basals
BR—wide radial (17)
Br—Brachial; brachials; narrow radial (17)
br—brachial
C—primibrachial; primibrachials; cirrus
CI—left posterior radial
CII—left anterior radial
CIII—anterior radial
CIV—right anterior radial
CV—right posterior radial
C_1—radial
C_2—first primibrachial
C_3—second primibrachial
c—stem; columnal
c′—first primibrachial
cd—centrodorsal
c.p.—ambulacrals
cr—compound radials
D—secundibrachial
Dc—secundibrachial
d—intersecundibrachial
Dist—secundibrachial
dst—secundibrachial
e—interambulacrals
F—distal arm segments
f—distal arm segments
h—armless radial
IAmb—interambulacral
iIAmb—interprimambulacral
iIIAmb—intersecundambulacral
IB—infrabasal; infrabasals; primibrachial
ib—infrabasal
IBB—infrabasal; infrabasals
IBr—interradius; interbrachial; interbrachials
ibr—interbrachial; interbrachials
iBrBr—interbrachials
IIBr—interbrachial; interbrachials
iIIBr—intersecundibrachial; intersecundibrachials
ID—intersecundibrachial
ii—intercalaries
IR—interradius; interradial; interradials
ir—internrachial
IRA—anal interradius; first anal plate
IX—anal interradius
JB—infrabasal; infrabasals
JBB—infrabasals
Jc—interbrachial
Jdc—intersecundibrachial
JR—interradial
Jtc—intertertibrachial
K—calyx
L—left
l—left
LT—left tube plate
lt—left tube plate
mt—middle tube plate
O—oral, orals
o—oral
OO—orals
P—tertibrachials; posterior
Pa—right tube plate
Pa, P_C, P_D, P_pP_1—pinnules (5)
p—posterior
post—posterior
PR—pararadial
Qc—quartibrachial
R—radial; radials; radius, right
R′—radianal
r—radial; right
r^1—radial; first primibrachial
r^2—first primibrachial
RA—radianal
Ra—radianal
ra—radianal; right anterior
Ri, R_1—inferradial
Rs, R_s—superradial
RT—right tube plate; right
rt—right tube plate
Sa—radianal
Sr—subradial (basal)
St—stem
SX—second anal plate (series)
Tc—tertibrachial
t—tube plate; tegminal
u—infrabasal
wp—hydropore
X—first anal plate
x—first anal plate
X.a.a.—anal interradius
1St—primaxil
2St—secundaxil
IAmb—primambulacral
IAx—primaxil
Iax—primaxil
IB—primibrachial
IBr—primibrachial; primibrachials
IBr_2—primaxil; 2nd primibrachial
IBrBr—primibrachials
Ibr—primibrachials
IIAmb—secundambulacrals
IIAx—secundaxil
IIax—secundaxil
IIB—secundaxil
IIBr—secundibrachial; secundibrachials
IIBrBr—secundibrachials
X (times)—first anal (13)

INCONSISTENCIES AND SOURCES OF CONFUSION IN CURRENTLY USED SYMBOLS

The system of abbreviations for crinoid parts that was devised by Wachsmuth and

Springer (1879–1886) was a natural one, for the most part, but it was based on a nomenclature (underbasals, costals, distichals, etc.) that has been discarded almost entirely. The symbols were used by Wachsmuth and Springer only in diagrams and not as substitutes for the names of parts in text discussions. It is obvious that the mode of designation of crinoid parts in diagrams, presumably explained in the legend, is relatively unimportant as compared with use of abbreviated designations for these same elements when incorporated in the text of a paper. The latter symbols should be well understood and should accord with a very general usage. Bather's revised designations for various crinoid parts accord with nomenclature that has become almost universally adopted, and the symbols that Bather employed, both for figures and text, have likewise come into general use.

Capitals versus lower case letters.—The Bather symbols were made, with few exceptions, by writing the initial letters of the terms or of their chief component parts, using capitals. Examples are *IB*, *B*, *R*, *RA* and *Br*. For identification of crinoid parts in diagrams lower case letters are not less acceptable than capitals, and it happens that Wachsmuth and Springer chose lower case letter symbols. For use in text, however, it seems obvious that capital letters stand out better as sign-posts. The eye readily picks out the capital letters and without difficulty recognizes their function as symbols, whereas this is less easily done if lower case letters, even in italics, are used. This is illustrated by the following three sentences of which the first follows the most common form of writing. The third form, using capital italics, seems decidedly preferable. (1) The armless laR and aR are smaller than RA and x. (2) The armless lar and ar are smaller than ra and x. (3) The armless *LAR* and *AR* are smaller than *RA* and *X*. It is possible to avoid the anomaly of a lower case letter at the beginning of a sentence but examples of this are found in recent papers. iBr are numerous (16, pp. 241, 243).

Inconsistent capitalization of currently used symbols is found in the case of *x* (instead of *X*) for first anal plate, *rt* (instead of *RT*) for right tube plate, *lt* (instead of *LT*) for left tube plate, *iBr* (instead of *IBr*) for interbrachial and *iAmb* (instead of *IAmb*).

Roman numerals.—The writing of *IBr* for interbrachial and *IAmb* for interambulacral is certainly as logical as use of *IR* for interradial and *IB* for infrabasal. There is conflict, however, in the case of *IBr* and *IAmb* as just used, with the now customary designations for primibrachial (*IBr*) and primambulacral (*IAmb*), respectively. This calls attention to confusion that is almost bound to exist between the capital letter *I* and the Roman numeral *I*. Ambiguity of usage is shown in the tables previously given. *IB* means infrabasal (improperly also used for primibrachial) and *IR* is abbreviation for interradial, but *IBr* has been taken to signify primibrachial instead of interbrachial. Jaekel (11), Wanner (33), and Marez Oyens (17) have tried to avoid confusion by omitting the capital letter I from the symbols, writing *JB* for infrabasal, *JBB* for infrabasals, and *JR* for interradial. Jaekel uses *Jc* for interbrachial, *Jdc* for intersecundibrachial and *Jtc* for intertertibrachial, but Wanner, Marez Oyens and others employ lower case *i* as initial letter for these plates. Adoption of *J* for compounding some symbols removes ambiguity but little else can be said in favor of it.

A solution of difficulties that seems to be very simple and applicable consistently to the formulation of crinoid symbols is the substitution of Arabic for Roman numerals wherever the latter have been used. The letter *I* could then be employed as needed and written uniformly as a capital. The symbol for primibrachial thus becomes *1Br*, secundibrachial, *2Br*, etc., and interbrachial, *IBr*, interambulacral *IAmb*, etc. This still leaves a rather objectionable similarity of form for first order symbols of the group under discussion, (*1Br*, *IBr*, *1Amb*, *IAmb* *I1amb*), especially when these are written or printed by hand, and special care in proofreading type-set text is required. Designation for intersecundibrachial (*I2Br*) too closely resembles *12Br*, etc. Another point as regards use of numbers in crinoid plate symbols is experience in teaching that shows a tendency of some students to confuse the numerical designation of rank with that denoting position of a plate in a series. For example, IBr_2 may erroneously be translated to mean first secundibrachial.

Another plan is offered by extending in altogether natural fashion the system of initial letters for symbols, as was done by Wachsmuth and Springer and by Bather, using Bather's terminology for parts, as primibrachial (not costal), secundibrachial (not distichal), tertibrachial (not palmar), primambulacral (not first ambulacral), intersecundibrachial (not interdistichal), etc. Thus, we may write *PBr* for primibrachial, *SBr* for secundibrachial, *TBr* for tertibrachial, *QBr* for quartibrachial, *PAmb* for primambulacral, *ISBr* for intersecundibrachial, etc. Symbols for brachials above the fourth order are little used, but if there is occasion for them, Roman (or Arabic) numerals are best in order to avoid duplication of initial letters: *VBr* (or *5BR*) for quintibrachial, *VIBr* (or *6Br*) for sextibrachial, etc. No possibility of confusion is seen in use of *P* for primi- and *P* for posterior, because need to distinguish posterior brachial or posterior ambulacral does not arise. On first thought, paleontologists who are familiar with the Roman numeral system for brachial, interbrachial and tegminal parts of a crinoid may be disinclined to follow the initial-letter plan for symbols as here outlined. We are convinced, however, that this proposed revision follows natural lines, completely avoids infelicities, including sources of ambiguity, in the present or an otherwise modified system, and promises general acceptability.

Position of plates in a circlet or series.— The names for position, anterior, posterior, left, and right, have been designated by various symbols. Recent common usage, however, has become fairly well fixed on *P* for posterior, *A* for anterior, *R* for right, and *L* for left, although often they have been written as lower case instead of capital letters. It is consistent and preferable to use capitals for these symbols. The manner in which *R*, meaning right, is combined with other symbols avoids possibility of confusion with *R*, meaning radial (for example, *RAB* for right anterior basal, *RPR* for right posterior radial).

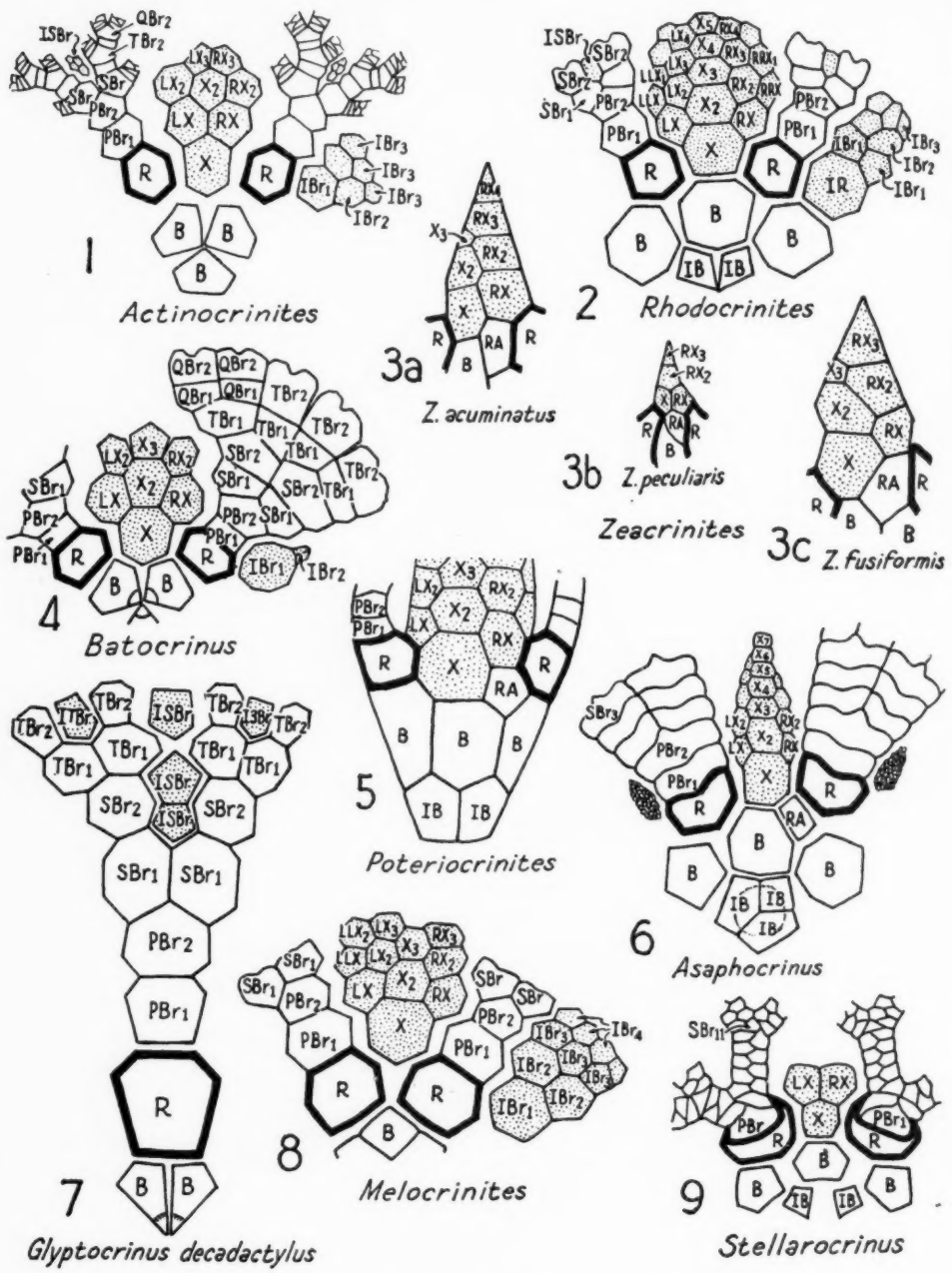
In dicyclic crinoids possible confusion arises, owing to the fact that the basals are offset from the normal mid-line through the ray plates. Usage of symbols for the radial and basal plates has given precedence to *AR*, anterior radial, and *PB*, posterior basal. Plates in the radial circlet thus read *AR*, *LAR*, *LPR*, *RPR* and *RAR*. Plates in the basal circlet read *PB*, *RPB*, *RAB*, *LAB*, and *LPB*. Because infrabasals fall normally in the same line with radials, it is natural to denote position of individual plates of the infrabasal circlet as in the radial circlet. Thus, infrabasal plates customarily are designated *AIB*, *LAIB*, *LPIB*, *RPIB*, and *RAIB*.

An individual plate in a brachial or interbrachial series has commonly been indicated by a subscript Arabic numeral, count being made distally from the proximal unit. No reason to modify this procedure is seen. Thus, PBr_3 signifies the third primibrachial, but *PBr* 3 is a condensed indication that there are three primibrachials.

Somewhat confusing is a dual designation of axillary brachial segments, for two different symbols are applicable to each such plate. The primaxil (*PAx*) may be the first primibrachial (PBr_1), as in *Stellarocrinus* (fig. 9) and many other crinoids, the second primibrachial (PBr_2), as in *Actinocrinites* (fig. 1), and others (figs. 2, 6, 7, 8), or it may higher in number. An axillary plate is invariably at the distal end of the brachial series to which it belongs and only one such plate occurs in each series. The position of the axillary may be indicated as PAx_1 (axillary first primibrachial) or SAx_5 (axillary fifth secundibrachial). This is clear enough, perhaps, but it is bothersome to many students. An alternative designation that is almost as concise and somewhat more natural is formed by combining the ordinary symbol for a given brachial, as SBr_5 (fifth secundibrachial) with *ax* (axillary), giving SBr_5ax (fifth secundibrachial axillary). The plan of arm branching in *Glytocrinus decadactylus* (fig. 7), may be indicated PBr_2ax, SBr_2ax, and in *Asaphocrinus* (fig. 6), PBr_2ax, SBr_3ax, $TBr_{6-10}ax$.

A few camerate crinoids, such as *Rhodocrinites* (fig. 2), and articulates are characterized by the presence of plates between the radials. Each of the intercalated plates in the radial circlet (except in the posterior interradius) is designated as an interradial plate (*IR*), but succeeding plates between the rays are classed as interbrachials (fig. 2).

In many camerate and flexible crinoids



TEXT FIGURES 1–9. (*See opposite page for explanation.*)

and some articulates the primary interbrachial plate lies in a position between the primibrachials (figs. 1, 4, and 8). Because all ray plates above the radials have commonly been designated as brachials, the remaining plates in the series above the primary interbrachial have been designated as interbrachials, even though eventually they lie between higher ray plates, such as secundibrachials or tertibrachials. This usage of terms seems desirable and for sake of simplicity in descriptions we recommend the practice of Wachsmuth and Springer (32, p. 253) in designating with Arabic numerals the number of plates in successive rows of an interbrachial (*IBr*) series. For example, in the case of a primary interbrachial followed by two interbrachials and these succeeded by three and four plates in consecutively higher rows (as in *Melocrinites*, fig. 8), the arrangement may be indicated by the statement: Interbrachials 1, 2, 3, 4, or *IBrBr* 1, 2, 3, 4.

The same possibility of confusion exists in plate series lying in the intersecundibrachial (*ISBr*) or intertertibrachial (*ITBr*) positions. Plates in the upper portions of these series may actually come to lie between brachials of a higher order (fig. 7). They should be designated likewise according to the lowest plate in the series. For simplicity in descriptions the use of numbers (as *ITBrBr* 1, 2, 1) is desirable.

The posterior interradius.—Designation of the radianal plate by the symbol *RA* is logical but the sign *X* has no evident relation to the first anal plate. The letter *A* (also written *a*) has been used to refer to the first anal plate, and this follows the plan of deriving other symbols for crinoid parts. To adopt *A* for anal plate is objectionable, however, mainly for the reason that *X* is a very long used, distinctive symbol, that fittingly sets this plate apart as one of the most important elements in crinoid morphology. The anal interradius defines orientation, and characters of this region are especially important in generic classification. *A* meaning anal plate, is less likely to be confused with *A*, meaning anterior, than with *A*, indefinite article, at the beginning of a sentence. It would be unwise to employ a symbol other than *X* for this key element of the crinoid test. If this is granted, question may be raised about changing *RA* to *RX*, inasmuch as the latter symbol combines the accepted designations for radial (*R*) and anal (*X*). *RX* might be deemed preferable to *RA* if we were just now commencing to use symbols, but nothing is gained and much is lost by discarding *RA*. The derivation of *RA* is consistent with the mode of formulating other symbols, and widespread usage during more than four decades favors retention of this abbreviation. *RX* may be used to designate the so-called second anal plate obliquely above *X* at the right and this symbol is definitely preferable to *rt* or *RT*, meaning right tube plate. *LX* may be used to mark the corresponding plate obliquely above *X* at the left.

The anal interradius offers special problems, in that detailed description of the anal series is often very desirable. As shown in foregoing tabulations, a variety of symbols has been employed by various authors to designate the plates of this area. In forms like *Reteocrinus*, *Rhodocrinites*, and *Glyptol*

EXPLANATION OF TEXT FIGURES 1–9

Text figures 1–9. Diagram showing arrangement of plates and symbols for designation of them in various types of crinoids. Radial plates are differentiated from others by a heavy border line and plates belonging to interbrachial positions are stippled.

1. *Actinocrinites*, showing basal circlet, posterior rays, anal interradius and right posterior interradius. 2. *Rhodocrinites*, posterior part of dicyclic dorsal cup, showing interradial, interbrachial and intersecundibrachial plates. 3. *Zeacrinites*, posterior interradius of three species, showing designation of anal plates (revised from Sutton and Hagan). 4. *Batocrinus*, posterior part of dorsal cup showing three bifurcations in one ray. 5. *Poteriocrinites*, posterior view of dorsal cup showing typical arrangement of anal plates. 6. *Asaphocrinus*, infrabasal circlet and posterior plates of a flexible crinoid, showing very numerous small interbrachial plates of the left and right posterior interrays. 7. *Glyptocrinus decadactylus*, plates of a ray, showing presence of intersecundibrachials and intertertibrachials. 8. *Melocrinites*, showing plates of the posterior part of cup. 9. *Stellarocrinus*, an inadunate crinoid having three anal plates in the dorsal cup and upward extensions of the radials between the arms.

crinus a conspicuous ray-like row of anal plates runs up the middle portion of the anal interradius. These plates have been regarded as anals by some authors (32) and the irregular plates lying at either side have been designated as interbrachials. In most camerate crinoids, however, the whole anal interradius is filled with irregular plates, making separation of designated anal plates from interbrachials practically impossible. Any given system of designation of anal plates within the anal series in camerate crinoids seems to break down in the case of a few forms, owing to the wide variation within these forms. Designation of the arrangement of plates in the anal series often may be made conveniently by use of numerals that indicate the number of plates in successive transverse rows, proceeding upward, as for *Actinocrinites* (fig. 1), anals 1, 2, 3, 2 (or *XX* 1, 2, 3, 2, or *X* 2, 3, 2).

In inadunate crinoids some confusion has arisen over symbols and terminology affecting anal plates above the *X* and *RA* plates. Most authors have designated as *rt* (right tube plate) the first plate of the anal series occurring obliquely above *X* at the right and more or less directly above *RA*. The plate next above *X* obliquely to the left, or in some cases directly above *X*, has been designated as *lt* (left tube plate). Goldring (7, p. 15) introduced the symbol *mt* (middle tube plate) for the plate that in some crinoids occurs directly above *X*, *lt* being identified as the plate at the left of *mt*, obliquely above *X*, and *rt* as the plate at the right of *mt*, obliquely above *X*. Sutton and Hagan (27), in describing the anal series of species of *Zeacrinites*, designated plates above *RA* and *X* in zigzag progression, using the terms second anal (*a2*), third anal (*a3*) and so on. Only two plates overlie *X* in some crinoids but in others the number is one or three. Wachsmuth and Springer (31) referred to the plates next following the first anal (*X*) as second anals, and classed all posterior interradial plates as anals, but in a later publication (32) they recognized both anals and interbrachials in this area. In cases where it is needful to distinguish individual plates of the anal series above the *X* plate it seems most convenient and natural to employ subscript numerals (as in designating individual brachials) for the plates in different vertical series,—X_2, X_3, X_4, etc., for plates directly above X_1; RX_2, RX_3, etc., for plates above *RX;* and LX_2, LX_3, etc., for plates above *LX*. Additional rows of anals at right (*RRX*) and left (*LLX*) of those already mentioned are present in some crinoids (fig. 2), but it is not necessary in most cases specially to refer to them.

PLURALIZATION OF SYMBOLS

Many categories of plates or ossicles in the crinoid skeleton are represented by more than one unit. A crinoid cup has a single radianal, or none at all, but typically there are 5 basals, 5 radials, 5 to 50 or more primibrachs, and so on. In diagrams the symbol for each element is commonly repeated as many times as required and placed where it belongs. This repetition doubtless suggested to Bather the mode that he introduced for indicating plural number of a symbol, as *BB* (basals) and *RR* (radials). The plural for infrabasal (*IB*) is written *IBB*, however, not *IBIB*, and plural number for several symbols, according to Bather, is the same as the singular, as *Amb* (ambulacral or ambulacrals), *Br* (brachial or brachials) etc. Ambiguity is introduced not infrequently by this usage and in some cases study of the context fails to remove obscurity. Marez Oyens (17) has circumvented the difficulty by extending the system of duplicating part of the symbol, as *IBrBr* (primibrachials), and *IIBrBr* (secundibrachials), but this is not done consistently, for he writes (p. 298) "die übrigen IBr_1" (the remaining first primibrachials).

Plural symbols are little used in drawings but are much needed in the text of crinoid descriptions, if symbols are employed at all for this purpose. Is there any simple way to indicate plural number other than by cumbersome duplication? Construction of the plural number in English, French, Italian, and Spanish is almost uniformly made by addition of -s to the singular form, but in German the plural is mostly indicated by adding -n, -en, or -e. In Russian and other languages rules differ. The plural symbols devised by Bather are as readily understood in one language as another and they have received very extensive international use. Accordingly, study indicates that it is better to recommend extension of the system of in-

dicating plurals by duplication of symbols or their parts, rather than to seek acceptance of another method. The fact of wide uniformity in use of symbols for crinoid parts is itself a deterrent from change that is not agreed to be needed. Occasional carelessness or error, such as in using *B* for basals or *BB* for basal (30), and so on, is not likely to be eliminated by a change of the system for indicating singular and plural numbers.

CONCLUSIONS

(1) Use of symbols for the designation of crinoid parts in paleontologic writing is desirable and should be extended. It contributes to conciseness, permits maximum condensation combined with clarity, and generally promotes ease and accuracy of understanding by the reader.

(2) The extent to which symbols should be employed in a given publication must be left to judgment of the author, but in any case, except possibly abbreviations for the most universally used elements (*IB*, *B*, *R*, *RA*, *X*), it is desirable that first appearance of a symbol should be accompanied by an explanation. This may be given in parentheses following the symbol or otherwise. Overspecialization and complexity of symbols defeats usefulness, except in uncommon instances. Unless a symbol is familiar to the average reader or is much needed, it is better to write the name in full.

(3) Capital letters are preferable to lower case letters in formulating symbols because they are more readily apprehended when used in the text of papers. This applies to abbreviations for anterior (*A*), posterior (*P*), etc., as well as to initial letters of some symbols (as *iBr*) that previously have been written in lower case. Also, it is preferable to use italics for symbols, but this is not necessary.

(4) Because of its identity of form with the capital letter *I*, the Roman numeral *I*, and higher Roman numerals, should be replaced by initial letters, *P* for primi-, *S* for secundi-, *T* for terti-, and *Q* for quarti-. This obviates the need to use an initial lower case *i*, removes some existing sources of confusion, and tends to simplify designation of brachial and tegminal elements.

(5) Symbols denoting plural number should uniformly differ from those for the singular number. The method of duplication of all or part of the symbol for a single element is deemed to be the most acceptable for indication of plurals. It is adapted to use in different languages and is established by usage.

(6) A table summarizing recommended symbols shows the relatively small number that is required more or less commonly for use in text discussions. Examination of the list indicates that the given symbols accord closely with those currently used by numerous paleontologists who have published studies on crinoids. This is less true of symbols previously used in papers of the present writers.

List of recommended symbols for crinoid parts

Infrabasal (*IB*), infrabasals (*IBB*); infrabasal circlet (*IB* circlet—not *IBB* circlet)
Basal (*B*), basals (*BB*); basal circlet (*B* circlet—not *BB* circlet)
Radial (*R*), radials (*RR*); radial circlet (*R* circlet—not *RR* circlet)
Anterior (*A*); posterior (*P*); left (*L*) right (*R*) (posterior basal), *PB*; left posterior basal, *LPB*; anterior radial, *AR*; right anterior radial, *RAR*; etc.
Anal (*X*), also called first anal or special anal, anals (*XX*), plates of the posterior interradius, excluding radianal; right second anal (tube plate) (*RX*), middle second anal (X_2), left second anal (*LX*)
Radianal (*RA*), regarded as synonymous with right posterior inferradial as currently defined in some inadunate crinoids.
Brachial (*Br*), brachials (*BrBr*)
Primibrachial (*PBr*), primibrachials (*PBrBr*); first primibrachial (PBr_1), first primibrachials ($PBrBr_1$), second primibrachial (PBr_2), etc.; axillary primibrachial or primaxil (*PAx*), primaxils (*PAxAx*); axillary first primibrachial or first primibrachial axillary (PBr_1ax), axillary second primibrachial (PBr_2ax), etc.
Secundibrachial (*SBr*), secundibrachials (*SBrBr*); first secundibrachial (SBr_1), etc.
Tertibrachial (*TBr*), tertibrachials (*TBrBr*), etc.
Interradial (*IR*), interradials (*IRR*), plates between rays.
Interbrachial (*IBr*), interbrachials (*IBrBr*), plates between primibrachials belonging to the same ray.
Intersecundibrachial (*ISBr*), intersecundibrachials (*ISBrBr*), plates between secundibrachials belonging to the same half-ray.
Oral (*O*), orals (*OO*)
Ambulacral (*Amb*), Ambulacrals (*AmbAmb*)
Interambulacral (*IAmb*), Interrambulacrals (*IAmbAmb*)

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PALEONTOLOGICAL NOTES

AN INCOMPLETE *BUETTNARIA* SKULL FROM THE DOCKUM BEDS OF TEXAS

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Included in the collections of vertebrate fossils of Walker Museum is an incomplete skull of a stereospondylous amphibian. The specimen (Walker Museum 1586) was collected by Dr. E. C. Olson during the summer of 1936, the locality being given as Home Creek pasture, 20 miles west of Spurr, Texas. The specimen is from the Dockum, Upper (?) Triassic and the scarcity of vertebrate remains from these beds makes it worth recording, but because of its fragmentary nature an extended description will not be attempted.

It does not seem wise to assign a specific name on such material, even when the genus is certainly known. On the basis of present knowledge, this specimen, while not certainly so, is very probably a member of the genus *Buettnaria* Case. In the general relationships of the bones which are present, on details of the skull sculpture, and on the basis of its stratigraphic location the specimen can hardly be referred elsewhere at present. However, the measurements (length of skull, and the breadth across the occipitals can be approximated fairly well) are only slightly over half those given by Case (1931) for *B. bakeri*, and about $\frac{2}{3}$ those of *B. perfecta*.

Length–breadth ratio

	B. perfecta	*B. bakeri*	*Buettnaria* sp. (W. M. 1586)
$\frac{\text{Length}}{\text{Breadth}}$	$\frac{443.2}{344.2}=1:0.8$	$\frac{321}{222}=1:0.69$	$\frac{175}{120}=1:0.7$

It will be noticed that the length-breadth ratio of *B. bakeri* and this specimen (W. M. 1586) are almost identical.

The occipital region of the skull is the most complete. It includes portions of the following bones: dermal supraoccipital, tabular, squamosal, exoccipital, pterygoid, and part of the left quadrate and stapes. There are various scattered portions of the skull roof, and the greater part of both lower jaws are present.

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NOTES ON THE SUBGENERA OF THE OSTRACODE GENUS *CYTHERIDEA*[1]

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ABSTRACT—Six subgenera of the ostracode genus *Cytheridea* are discussed. These include the subgenera *Cytheridea*, *Haplocytheridea*, *Clithrocytheridea*, *Dolocytheridea*, *Leptocytheridea*, and *Phractocytheridea*. One new species, *Cytheridea* (*Haplocytheridea*) *wadei*, is described from the Miocene of Florida.

Bosquet (1852) erected the ostracode genus *Cytheridea*, and defined its shell characters. The genotype, *Cytheridea mülleri* (Münster), appears first to have been designated as the type species by Brady and Norman (1889).

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A brief account of the more important work dealing with the genus *Cytheridea* was included in a paper by the author (Stephenson, 1936), which more closely defined the shell characters of the type species. A study of American Tertiary species of the genus indicated these species possessed shell structures which were distinct from the genotype. The type species, *C. mülleri* (Münster), were placed under the subgenus *Cytheridea* (Bosquet).

Tertiary species of *Cytheridea* from the Gulf Coast, for the greater part, were found to fall into two groups. For these two variants in the shell structure of the genus *Cytheridea*, I proposed the subgenera *Haplocytheridea* and *Clithrocytheridea* (Stephenson, 1936). Subsequent studies have disclosed the presence of a number of species in the Gulf Coast section possessing shell characters as defined for these subgenera. The hinge structure within the two groups is only slightly variable. Reported variants in the muscle scar pattern are, however, more pronounced, and a few of these variations have been reproduced in the present report (text figures 9–11, 13). As *Haplocytheridea* and *Clithrocytheridea* seem quite distinct groups within the genus *Cytheridea*, I feel that these two subgenera should be upheld.

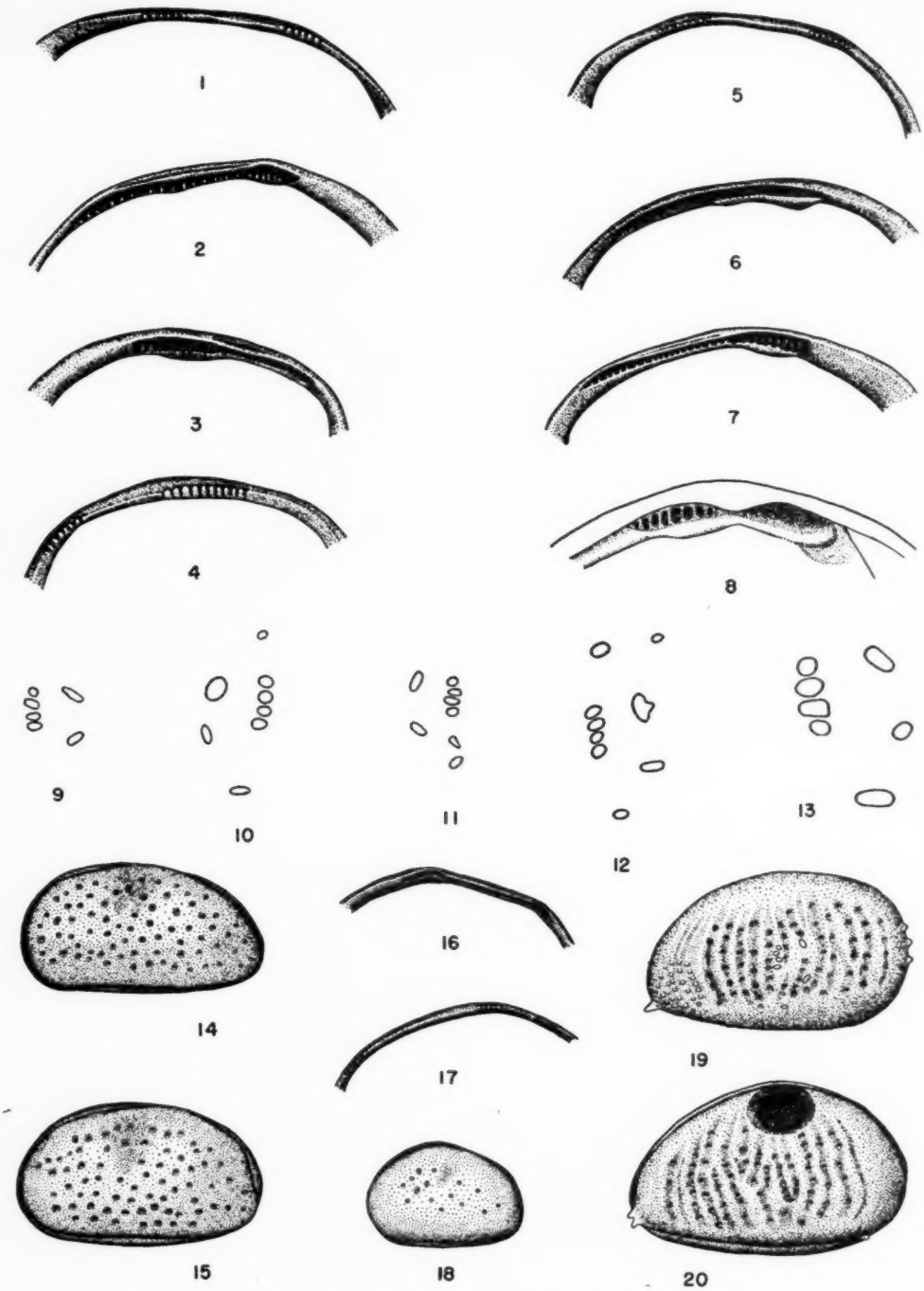
It is of interest to note that Triebel (1938), in his work on the Ostracoda of the lower Kreide of Germany, reported a number of species of both *Haplocytheridea* and *Clithrocytheridea*. Triebel classified none of his species under the subgenus *Cytheridea*, a form which I have never seen in the Tertiary section of the Gulf Coast. In this work, however, Triebel (1938, p. 494) proposed a new subgenus, *Dolocytheridea*, under the genus *Cytheridea*. The subgenotype chosen was *Cytherina hilseana* F. A. Roemer. The carapace was described as egg-shaped to almost cylindrical; dorsal margin not strongly arched, especially in the male, with weak cardinal angles; surface without strong sculpture. The hinge structure of the left valve was indicated to consist of two elongate dental sockets, sometimes connected by a very short furrow, but without the development of an elongated furrow; upper margin of tooth sockets formed by the somewhat overhanging dorsal margin of the valve. In the right valve, hinge with two elongate dental plates, of which only one was said to be distinctly notched; or the notched teeth might be absent on both dental areas, in which case the corresponding notches in the tooth sockets of the left valve were also lacking. Middle hinge line of the right valve formed by a smooth ridge. Inner margin and line of concrescence were noted to coincide or to be separated a short distance on the anterior end.

The subgenus *Dolocytheridea* appears to be somewhat similar to *Haplocytheridea*. The principal means of distinction seem to be the hinge structure and muscle scar pattern. The hinge line of a left valve of the genotype (text fig. 8), and the muscle scars (text fig. 12), are included in this report, both adapted from Triebel. I have had no opportunity to study specimens of this subgenus.

In a study of Eocene and Oligocene species of *Cytheridea* from the Gulf Coast (Stephenson, 1937, p. 156), I proposed the subgenus *Leptocytheridea*. Under this subgenus, I included a number of forms which possessed a thin, usually smooth or weakly ornamented carapace. As I worked with more of these fragile types, I encountered variations within the group, and the shell characters seemed less consistent than I had at first considered them.

For some time, I have suspected that the forms which I included under *Leptocytheridea* were in reality young moults of larger, heavier species assigned to other subgenera. Little work has been done, however, on the life history of the Ostracoda, and I know of no study dealing with moulting in this group. Howe (Howe and Law, 1936, pp. 57, 58), in erecting the genus *Archicythereis*, suggested the strong probability that species referred by him to this genus might well be the young moults of other genera. In dealing with the fossil Ostracoda, however, it is often difficult to establish the relationship between adult carapaces and possible young moults of the same species.

Doctor Henry V. Howe, of Louisiana State University, called my attention to the new species described in this report. *Cytheridea* (*Haplocytheridea*) *wadei* Stephenson, n. sp., occurs in the *Pecten* bed of the upper Miocene exposure at Jackson Bluff, Leon County, Florida. The species is the only



TEXT FIGURES 1–20. (*See opposite page for explanation.*)

Cytheridea which I encountered in material examined from the *Pecten* bed. All available specimens of the new species exhibit the anomoly of reversal of the valve size and hinge structure normal for the genus. In addition to adult carapaces, the sample yielded numerous small, more fragile specimens of *Cytheridea*, the shape and shell characters of which are closely similar to *C.* (*H.*) *wadei*. The smaller form likewise shows the same reversal of hinge structure and valve size as the adult specimens. The conclusion seems well founded that these smaller carapaces of *Cytheridea* are young specimens or young moults of *C.* (*H.*) *wadei*, and that they do not constitute a distinct species to be assigned to *Leptocytheridea*. I am convinced that *Leptocytheridea* is not a valid subgenus of the ostracode genus *Cytheridea*, and feel that it should be abandoned.

A recently published study of Claiborne Eocene Ostracoda from the Weches formation of Texas, by Sutton and Williams (1939), included descriptions of four new species of the genus *Cytheridea*. Through the courtesy of Doctor A. H. Sutton, of the University of Illinois, I have been able to study the type specimens of these new species. A rather large suite of specimens from the Weches formation at Smithville, Texas, in my own collection, also has aided in the study of these species.

C. (*H.*) *habropapillosa* Sutton and Williams falls readily under the subgenus *Haplocytheridea*. The form described as *C.* (*H.*) *subovata* Sutton and Williams likewise belongs under this subgenus, although the specific name was preoccupied, and has been changed to *C.* (*H.*) *bastropensis* (Sutton and Williams, 1940). The species described as *C.* (*H.?*) *subpyriformis* should be assigned to the subgenus *Clithrocytheridea*.

C. (*Phractocytheridea*) *compressa* Sutton and Williams was designated as the subgenotype of the new subgenus *Phractocytheridea*, which the authors proposed to include this species. Viewed from the exterior, I find it very difficult to separate this species from *C.* (*H.*) *bastropensis*, and the original figures of the two species (Sutton and Williams, 1939, pl. 64, figs. 23–28) indicate this strong similarity. From the interior, right valve specimens of the two species are difficultly separable. *C.* (*P.*) *compressa* is somewhat lower with less pronounced cardinal angles; the bar between the terminal teeth of the hinge is not separated from the dorsal margin by an incised line; and the ventral flange appears to be somewhat more to the posterior. In the left valve, *C.* (*P.*) *compressa* possesses a slightly better development of the ventral flange, which is situated farther to the posterior, the sockets and connecting groove of the hinge are also only slightly crenulate, and the anterior socket is well incised in a moderately heavy plate.

The subgenus *Phractocytheridea* appears to me to have been too narrowly defined, and based on too slight variants in shell

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EXPLANATION OF TEXT FIGURES 1–20

All figures ×75, unless otherwise indicated

FIGS. *1, 2, 7, 20*—*Cytheridea* (*Haplocytheridea*) *bastropensis* Sutton and Williams. *1, 2*, Hinge structure of right and left valves, paratypes, U. I. X.-1254, 1253. *7*, Variant in hinge structure of left valve, hypotype, Howe coll., no. 2295. *20*, Right valve view, holotype, U. I. X.-1252. Fig. *20*, ×50.

3, 4, 14–18—*Cytheridea* (*Haplocytheridea*) *wadei* Stephenson, n. sp. *3, 4*, Hinge structure of right and left valves, paratypes, Howe coll., nos. 2290, 2291. *14*, Left valve view of male adult, holotype, Howe coll., no. 2288. *15*, Left valve view of female adult, paratype, Howe coll., no. 2289. *16, 17*, Hinge structure of right and left valves, young specimens, paratypes, Howe coll., 2293, 2294. *18*, Left valve view of young specimen, paratype, Howe coll., no. 2292. Figs. *14, 15, 18*, ×50. (p. 428)

5, 6, 11, 19—*Cytheridea* (*Haplocytheridea*) *compressa* Sutton and Williams. *5, 6*, Hinge structure of right and left valves, syntypes, U. I. X.-1262, 1261. *11, 19*, Muscle scar pattern and exterior of right valve, syntype, U. I. X.-1262. Fig. *19*, ×50.

8, 12—*Cytheridea* (*Dolocytheridea*) *hilseana* (Roemer). Hinge structure and muscle scar pattern of a left valve. (Adapted after Triebel).

9—*Cytheridea* (*Haplocytheridea*) *montgomeryensis* Howe and Chambers. Muscle scar pattern.

10—*Cytheridea* (*Haplocytheridea*) *kummi* Triebel. Muscle scar pattern (After Triebel).

13—*Cytheridea* (*Clithrocytheridea*) *decumana* Triebel. Muscle scar pattern (After Triebel).

structure. The anterior hinge socket of the left valve is incised in a heavier plate than most species of *Haplocytheridea*, and it is the lower portion of this plate which the authors refer to as a "flange." The absence of an incised line between hinge teeth and dorsal margin of the right valve seems a doubtful criterion, as the original description of *Haplocytheridea* (Stephenson, 1936, p. 700) described this feature as "an almost imperceptible line." It is possible to determine typical specimens of the new subgenus, but intermediate forms from the type locality are difficult of assignment. One variant in the hinge structure of the left valve is figured (text fig. 7). The "flange" below the anterior socket of the left valve, characteristic of *Phractocytheridea*, is well developed. Both sockets and groove are deeply notched, however, which does not agree with the original description, defining these notches as

> so weakly developed that they are visible only when the illumination is from a favorable angle (Sutton and Williams, 1939, p. 572).

A number of slight variants and intermediate forms between *C.* (*H.*) *bastropensis* and *C.* (*P.*) *compressa* occur at other Claiborne Eocene localities in the Gulf Coast. These variants appear to me to be of specific rather than subgeneric rank. It seems preferable, therefore, to consider *C.* (*H.*) *bastropensis* and *C.* (*P.*) *compressa* as two closely allied species of the subgenus *Haplocytheridea*, and to consider the shell structure exhibited in the type species of *Phractocytheridea* as a variant of *Haplocytheridea*.

SYSTEMATIC DESCRIPTIONS

Family CYTHERIDAE Baird, 1850

Genus CYTHERIDEA Bosquet, 1852

Subgenus HAPLOCYTHERIDEA Stephenson, 1936

CYTHERIDEA (HAPLOCYTHERIDEA) WADEI Stephenson, n. sp.

Text figures 3, 4, 14–18

Carapace of the male in side view low, elongate; right valve of all available specimens larger than the left, overlapping around entire periphery with greatest overlap along ventral margin. Anterior end broadly and evenly rounded, posterior end narrower and sloping to the bluntly pointed postero-ventral angle; dorsal margin very gently arched with weak cardinal angles, flattened along the hinge line, and sloping gently toward the posterior; ventral margin straight or slightly convex. General surface smooth, showing a moderate number of fairly deep pits, the area between pits appearing faintly granular under higher magnifications. A moderately incised oblique median vertical sulcus, surrounded by a depressed area of the carapace wall, and extending from a point near the dorsal margin to the center of the carapace, is visible on most specimens. Interior of valves shallow. Hinge structure rather weak, in the right valve consisting of a long, shallow, faintly notched anterior socket, and a much shorter, less conspicuous, notched posterior socket. Between the terminal sockets and continuous with them extends a slightly depressed, granular to faintly notched groove. In the left valve, hinge with a long, narrow, faintly notched anterior dental area. The terminal dentitions are continuous with and only slightly more prominent than the raised rim extending around the entire inner periphery of the valve. The dentitions are truncated gently into the lower, faintly notched bar between them, which is separated from the dorsal margin by a shallow depressed area. Around the anterior and posterior ends of the smaller left valve, outside and adjacent to the raised peripheral rim, is a shallow groove for the reception of the right valve. Marginal areas of moderate width, with the line of concrescence coinciding with the inner margin. Radial pore canals straight, fairly numerous. Muscle scar pattern a vertical row of four small scars, with two more anterior to them.

Remarks.—Sexual dimorphism is marked in this species. In side view, the female carapace is more broadly rounded, with a much higher postero-cardinal angle, a more steeply sloping posterior end, and a more rounded postero-ventral angle. The female is likewise more tumid, the inflation being particularly pronounced posterior to the median vertical sulcus. All specimens in my collection exhibit the anomaly of reversal in valve size and characters of the hinge line.

This is the only species of *Cytheridea* encountered in this sample. There are also present, however, numerous specimens of a

much smaller, more fragile form of *Cytheridea* (text fig. 18). These smaller specimens possess an identical surface ornamentation to that exhibited by *C.* (*H.*) *wadei*, although more weakly developed. These fragile specimens likewise show the same reversal in valve size and hinge structure as seen in the adult form of *C.* (*H.*) *wadei*. While possessing shell characters which could place them as a different species to be assigned to the subgenus *Leptocytheridea*, I feel sure that this small form would erroneously be assigned there. These specimens almost certainly should be classed as young specimens of *C.* (*H.*) *wadei*, or as young moults of the species.

The new species is named in honor of Wade H. Hadley, Jr., geologist for Pure Oil Company at Baton Rouge, La.

Occurrence.—The type locality of the species, the *Pecten* bed in the upper Miocene exposure at Jackson Bluff, Leon County, Florida, is the only station from which I have seen the species. The material examined was collected by Doctor H. N. Fisk, of Louisiana State University.

Types.—The type specimens upon which this species is based have been deposited in the Henry V. Howe collection, Louisiana State University, University, La. Holotype, no. 2288, a complete specimen of a male; paratypes, nos. 2289–2294.

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MANUSCRIPT RECEIVED BY THE EDITOR FEBRUARY 10, 1941.

AN *ATURIA* FROM THE TONGA ISLANDS OF THE CENTRAL PACIFIC

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ABSTRACT—*Aturia* cf. *A. aturi* (Basterot) is described from the island of Eua in the Tongan archipelago. It occurs there in a bedded volcanic tuff which is probably Miocene in age.

Representatives of the nautiloid cephalopod genus *Aturia* are widespread and they are known from all of the continents. Their occurrence in Australia, Tasmania, and New Zealand was noted long ago, and recently some fragmentary specimens have been reported from Java. None has so far been described from Polynesia, and therefore it seems worth while to publish illustrations and a description of a typical form from the Tonga Islands.

The specimen under consideration is one of five that were collected by J. E. Hoffmeister on the island of Eua at the southern end of the Tongan archipelago. According to Hoffmeister (1932, pp. 18, 33), it came from about 690 feet above sea level in a horizontally bedded volcanic tuff which overlies an Eocene limestone. Pelagic Foraminifera from the same formation were determined by J. A. Cushman to represent the genera *Orbulina*, *Globigerina*, *Globoratalia*, and *Cassidulina*, and to be either Miocene or Pliocene in age. The *Aturia* is com-

patible with this age assignment but it cannot be said to establish it. That is, this specimen has a rather advanced type of suture, and its conch is strongly compressed laterally and is subdiscoidal in shape. Similar congeneric forms are known to occur as early as the Eocene, but they are more characteristic of the later Tertiary, particularly the Miocene. Reeside, who examined the Tonga representatives of *Aturia* several years ago and recognized their generic affinities, also concluded that the containing beds are probably Miocene in age, as did Hoffmeister, who studied the strata in the field.

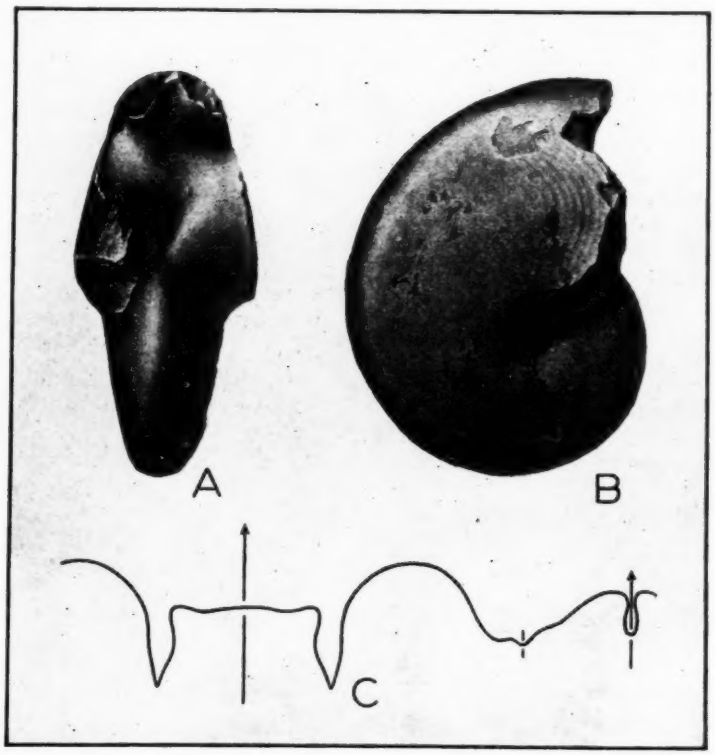

FIG. 1.—*Aturia* cf. *A. aturi* (Basterot) from the Tertiary (Miocene?) of Eua, Tonga Islands. Ventral and lateral views and diagrammatic representation of a suture, all ×1.

ATURIA cf. A. ATURI (Basterot)
Figures 1A–C

Aturia sp. HOFFMEISTER (*fide* REESIDE), *1932*, Bernice P. Bishop Museum Bull. 96, pp. 18, 33.

The only specimen available for study is an internal mold which is septate throughout. It is about 58 mm. in diameter, and near its adoral end its conch is about 36 mm. high and about 25 mm. wide. However, the specimen has been slightly crushed laterally and therefore originally its conch may have been a little wider. The surface of the test is smooth, but faint traces of growth-lines can be discerned on it. These form broad rounded lateral salients and a deep ventral sinus. The umbilicus is small and is not prominent.

Near the adoral end of the specimen, each suture forms a broad almost flat straight-sided ventral saddle and on either side of it a very much narrower pointed lateral lobe, a broad high broadly rounded lateral saddle, a broad rather deep asymmetrical lobe on the umbilical portion of the conch and a broad rounded asymmetrical internal lateral saddle which extends to the narrow spatulate dorsal lobe (fig. 1C). The top of the

ventral saddle is slightly sinuous, and a pair of very shallow rounded secondary lobes, one on either side of the venter, divide it symmetrically into three low rounded secondary saddles. Also, the bottom of the lobe on the umbilical portions of the conch is sinuous, and apparently a pair of low rounded saddles, one on either side of the umbilical seam, divide it into three small unequal lobes. The siphuncle is located close to the dorsum in an adapical infundibular flexure of the septa.

Remarks.—*A. aturi*, the genotype of *Aturia*, was originally described from the Miocene of St. Paul de Dax in southwestern France. According to Professor Hoffmeister, the above-described Tonga specimen is of about the same size as the four presumably conspecific specimens that were found in association with it; nevertheless, it is rather small for this genus and probably represents only the inner volutions of the conch. Insofar as can be told from the literature, all of its characters that can be ascertained do not differ materially from those of typical *A. aturi*, but it is not possible to determine its specific affinities with certainty. Possibly, it should be referred to *A. australis* McCoy, but it is very doubtful if that form can be distinguished from typical *A. aturi*.

Occurrence.—Fairly abundant in a horizontally bedded volcanic tuff of Upper Tertiary (Miocene?) age at one locality (Hoffmeister's Station 105) in the east-central portion of Eua, Tonga Islands.

Repository.—University of Rochester.

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MANUSCRIPT RECEIVED BY THE EDITOR OCTOBER 14, 1940.

THE FORAMINIFERA OF RED BLUFF[1]

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ABSTRACT—A check list of the foraminifera of Red Bluff, Wayne County, Mississippi, is herewith presented in comparison with subjacent and superjacent beds.

The marine beds near Red Bluff Station, Wayne County, Mississippi, were first mentioned by Hilgard[3] in 1860 in his report on the Agriculture and Geology of Mississippi. From this report it is impossible to locate the exact spot to which Hilgard had reference.

M. C. Israelsky and the writer selected and sampled a bluff two and one-fourth miles north of Hiwanee Station, Mississippi, on the Chickasawhay River, NE ¼, sec. 16, T. 10 N., R. 7 W., Wayne County, Mississippi, which seemed to offer the most complete section. Approximately seventy feet of marine beds are exposed here, affording the following profile:

SECTION OF BLUFF TWO AND ONE-FOURTH MILES NORTH OF HIWANEE STATION ON CHICKASAWHAY RIVER

	Feet
Terrace material of vari-colored clay	
Buff clay	10
Greenish-gray clay	8
Brownish-gray fossiliferous clay	3
Blue-green glauconitic clay	6
Blue-green clay	43

[1] Published by permission of Walter H. Spears of the Union Producing Company, Shreveport, Louisiana.

[2] Paleontologist, Union Producing Company, Houston, Texas.

[3] Hilgard, Agriculture and Geology of Mississippi (1860), pp. 135–136.

Check List of Red Bluff Foraminifera	McElroy	Bottom	Bottom plus 8′	Bottom plus 15′	Bottom plus 25′	Bottom plus 40′	Bottom plus 43′	Bottom plus 49′	Bottom plus 52′	Bottom plus 60′	Bottom plus 70′	Type Vicksburg
Angulogerina byramensis						×		×	×		×	×
A. danvillensis	×	×	×			×					×	×
A. rugoplicata	×										×	×
A. vicksburgensis											×	×
Anomalina bilateralis	×								×	×	×	×
A. cocoaensis			×	×	×	×						
A. danvillensis	×	×	×	×	×	×						
Asterigerina bracteata									×			
Bifarina vicksburgensis									×	×	×	×
Bitubulogenerina aperta										×		×
Bolivina caelata						×						
B. gardnerae					×							
B. gracilis	×	×	×	×	×	×			×			
B. jacksonensis	×		×	×		×	×					
B. jacksonensis var. *striatella*		×	×	×	×	×	×	×				
B. mexicana var. *horizontalis*	×		×		×	×						
B. mississippiensis	×	×									×	×
B. plicatella												×
B. tongi		×			×	×	×	×				
Bolivinella compressa										×		×
B. subpectinata										×		×
B. vicksburgensis												
Bulimina cooperensis						×						
B. jacksonensis	×	×	×	×	×	×	×	×	×			
B. ovata	×	×	×	×	×	×						×
B. pyrula	×							×	×	×	×	
Buliminella sp.		×	×		×	×						
Cancris brongniartii		×	×	×	×	×		×	×			
Cassidulina crassa	×											
Cassidulinoides brazilliensis	×	×	×		×							
C. globosa	×		×									
Ceratobulimina contraria	×			×	×	×						
Cibicides americanus	×	×		×	×	×		×	×	×		
C. lobotulus	×			×	×	×		×	×	×		
C. cf. *mexicana*					×				×	×	×	×
C. pseudoungerianus											×	×
C. yazooensis	×	×				×		×	×		×	×
C. sp.						×						
Clavulina byramensis		×	×	×		×		×	×	×		×
Cornuspira olygogyra	×					×				×		
Cyclammina sp.										×		
Dentalina catenulata										×		×
D. consobrina var. *emaciata*	×	×	×		×	×						
D. jacksonensis	×			×	×	×						
Discorbis assulata	×								×		×	
D. aff. *globulo-spinosa*	×	×										
D. cf. *subauricana*			×				×	×				
Epistomina elegans	×	×		×	×	×	×	×	×			
Eponides cf. *byramensis*										×	×	×
E. cocoaensis		×	×	×	×	×						
E. jacksonensis	×	×	×			×			×			
E. minima				×		×						
E. ouachitaensis	×				×				×	×		
E. sp. (round)								×	×	×		
E. sp.		×					×				×	×
Entosolenia laevigata	×										×	×
E. orbignyana var. *flinti*											×	×

Check List of Red Bluff Foraminifera	McElroy	Bottom	Bottom plus 8′	Bottom plus 15′	Bottom plus 25′	Bottom plus 40′	Bottom plus 43′	Bottom plus 49′	Bottom plus 52′	Bottom plus 60′	Bottom plus 70′	Type Vicksburg
Flabellina vicksburgensis			×	×		×				×		×
Frondicularia garretti			×			×						×
F. tenuisima		×	×	×	×	×						
Gaudryina jacksonensis		×	×			×	×					
Glandulina laevigata var.	×	×				×						×
Globigerina bulloides	×	×						×				×
G. cf. *ouachitaensis*	×					×						
G. triloba								×				
G. sp.		×	×	×	×	×	×		×		×	
Globorotalia cocoaensis	×	×	×		×	×						
G. sp. (n. sp.)			×	×		×						
Globulina gibba	×	×	×	×		×		×	×		×	×
G. gibba fistulose var.	×		×									×
G. spinosa									×	×	×	×
Gumbelina sp.			×			×						
Guttulina aegualis										×		×
G. austriaca	×	×	×							×		×
G. irregularis	×	×		×	×	×			×	×	×	×
G. problema	×	×									×	×
Gyroidina danvillensis	×	×				×					×	
G. vicksburgensis						×	×	×	×	×	×	×
Hantkenina alabamaensis	×	×	×	×	×	×			×		×	
H. brevispina	×	×	×			×						
H. mccordi	×	×		×		×						
Karreriella advena	×	×	×	×		×				×		×
Lagena cookei		×	×	×	×	×			×		×	×
L. hispida	×		×		×							
L. hexagona	×	×	×			×						×
L. laevis	×					×						
L. ouachitaensis	×	×				×						
L. striata	×	×	×	×	×	×					×	×
L. sulcata	×	×	×	×	×	×						×
Lamarckina glabrata									×	×		×
Lenticulina crassa			×		×	×	×	×	×	×	×	×
L. cultrata	×		×									
L. propinqua	×	×	×						×			×
L. vicksburgensis							×	×	×	×	×	×
Liebusella byramensis var. *turgida*		×	×	×	×							
Marginulina cocoaensis		×	×	×	×	×	×					
Marginulina cf. *jacksonensis*	×		×				×					
M. legumen		×	×									
M. cf. *sublituus*		×	×	×	×	×	×		×	×	×	×
M. subrecta	×			×		×						
M. triangularis	×					×						
M. sp. (new)		×			×	×						
M. sp.				×		×						
Massilina decorata	×	×	×	×	×	×		×	×			×
M. cf. *humblei*	×			×	×	×						
Nodosaria fissicostata		×		×	×	×	×		×			
N. longiscata	×	×	×	×	×	×	×	×		×	×	
N. vertebralis	×	×	×	×	×	×			×			×
N. sp.				×								
Nonion advenum	×							×			×	×
N. hantkeni	×			×	×	×			×		×	
N. hantkeni var. *spissa*	×	×	×									
N. micrus	×	×	×	×	×	×						×
N. planatum	×							×	×	×	×	×

Check List of Red Bluff Foraminifera	McElroy	Bottom	Bottom plus 8′	Bottom plus 15′	Bottom plus 25′	Bottom plus 40′	Bottom plus 43′	Bottom plus 49′	Bottom plus 52′	Bottom plus 60′	Bottom plus 70′	Type Vicksburg
Nonionella jacksonensis	×		×			×		××				
N. tatumi								××			×	×
Planularia ouachitaensis	×	×	×	×	×	×						
Planulina cocoaensis			××	×	×	××	×				×	
P. cocoaensis var. *cooperensis*		×	××	××		×						
P. sp. (new)			×	×	×							
Planorbulinella larvata									×			
Polymorphina advena var. *nuda*						×					××	×
P. frondea	×	×	×	×							××	×
Plectofrondicularia sp.					×							
Pseudoclavulina cocoaensis		×	×	×	×	×						
Pseudoglandulina radicula		×	×	×	×	×						
Pulvinulinella danvillensis	×				×							
Pyrgo inornata										×		×
Quinqueloculina contorta										×		×
Q. longirostra				×	×	×			×			
Q. seminula	×			×								×
Q. vulgaris									×			××
Ramulina sp.	×	×	×		×							××
Reusella spinulosa var. *glabrata*										×		×
R. subrotundata		×				×						
Robulus alato-limbatus	×				×			×				
Robulus arcuato-striatus var.	×	×		×								
R. carolinianus	×	×	×	×	×				×			
R. articulatus var. *texanus*												
R. (?) *danvillensis*	×				×							
R. gutticostatus			×				×	×				
R. gutticostatus var. *cocoaensis*		×	×	×	×	×	×	×	×			
Rotaliatina mexicana			×		×						×	
Saracenaria italica	×		×	×	×	×	×			×		×
S. sp. (beaded sutures)		×	×									
S. sp. (new ?) Flanged Keel				×								
Sigmomorphina jacksonensis	×	×				×						
Siphonina advena var. *eocenica*	×	×	×	×	×	×	×	×	×	×	×	
Spiroloculina grateloupi						×						×
S. sp.			×	×								
Textularia danvillensis	×		×	×	×	×						
T. cf. *dibollensis* var. *humblei*	×	×			×							
T. mississippiensis	×	×	×	×	×	×	×	×	×	×	×	
T. cf. *tumidula*										×		×
Triloculina sp.				×								
Uvigerina cf. *alata*	×			×	×				×			×
U. cocoaensis	×	×	×	×	×	×		×		×		
U. gardnerae	×			×	×	×	×	×				
U. gardnerae var. *texana*	×	×	×		×	×	×					
U. glabrans	×	×				×	×	×				
U. iopilensis	×	×	×									
U. cf. *vicksburgensis*						×			×		×	×
Valvulineria jacksonensis				×			×					
V. sculpturata											×	×
V. texana	×					×						
Vulvulina advena		×	×	×								
V. sp.		×										
Virgulina cf. *dibollensis*	×	×	×						×			
V. sp. (inflated)		×		×	×	×						
V. sp. (deflated)			×		×	×						

The writer wishes to express his gratitude to Julius B. Garrett for the use of his samples in checking the upper part of the bluff and to Dr. H. V. Howe for checking the foraminiferal determinations. The writer is also indebted to M. C. Israelsky for his constructive criticism and aid in collecting samples.

HISTORY

As early as 1860 Hilgard[4] noted that part of the beds "about a mile from Red Bluff Station" contained both Vicksburg and Jackson macrofossils.

He said:

> The fossiliferous bed number two (which is approximately fifty-two feet above low water level) seems to stand intermediate, by position as well as by its fossils, between these two groups, though on the whole, it seems in its fauna to approach more nearly the Vicksburg than the Jackson Group; but while it has some fossils in common with each and both of the other groups, it is no less remarkable for the predominance of peculiar species.

In 1923 C. Wythe Cook[5] reported on the Red Bluff and gave the following opinion:

> The Red Bluff fauna is unmistakably marine. It includes more than 128 Mollusks, 6 Corals 36 Bryozoa, and 50 Foraminifera. Of the 134 Mollusks and Corals, about 60 appear to be restricted to the Red Bluff beds; about 55 varietal or specifically identified forms are present in the Mint Spring Marl; and about 49 species or varieties are known in the Byram Marl. Twelve Mollusks, three of which range through the Vicksburg group, are listed also from the Jackson formation, but some of them are characterless species of supposedly very long range.

STRATIGRAPHY

The purpose of this paper is not to place these beds in either the Eocene or Oligocene, but to point out their close affinity to both. The check list, however, shows approximately forty-nine species occurring in the McElroy[6] which do not occur in the type Vicksburg; approximately thirty-six species occur in the type Vicksburg which do not occur in the McElroy, and at least eighteen distinctive species are restricted to this horizon.

The writer considers as significant the fact that a major part of the Foraminifera occurring above the McElroy is present only in the upper eighteen feet of the bluff, thus giving the upper part a closer affinity to the Vicksburg than the lower part. The lower fifty-two feet are in turn more closely allied to the McElroy. Of the forty-nine species occurring only in the McElroy and lower beds thirty-five species occur in the lower fifty-two feet of the bluff added to four species which are not present above the fifty-two foot level; of the thirty-six species occurring in the type Vicksburg twenty-one species do not occur below the fifty-two foot level.

Although no attempt is made here to place these beds in either the Eocene or Oligocene, it becomes apparent that if the Whitsett,[7] Cooper Marl,[8] and *Cristellaria* Zone[9] beds are Eocene, the beds at Red Bluff are of the same age. The writer is inclined to agree with E. Monsour in his suggestion that a separate stage or transition zone exists between the two formations.

The precise determination of the age to which these beds belong, from an economic standpoint, is of little significance; however, they are easily recognized and of stratigraphic importance.

[4] *Op. cit.*, pp. 135–136.

[5] C. Wythe Cook, *The Correlation of the Vicksburg Group*, U. S. Geol. Survey, Prof. Paper 133, p. 2.

[6] McElroy as used by A. C. Ellisor, *Jackson Group of Formations in Texas with Notes on Frio and Vicksburg*, Bull. Amer. Assoc. Pet. Geol., Vol. 17, No. 11 (Nov. 1933) pp. 1303–1309.

[7] *Op. cit.*, pp. 1310–1317.

[8] J. A. Cushman, *Upper Eocene Foraminifera of the Southeastern United States*, U. S. Geol. Survey, Prof. Paper 181, p. 2.

[9] E. Monsour, *Micro-Paleontologic Analysis of Jackson Eocene of Eastern Mississippi*, Bull. Amer. Assoc. Pet. Geol., Vol. 21, No. 1 (January, 1937), pp. 80–96.

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 4, PP. 436–439, JULY, 1941

REVIEWS

SMALL FORAMINIFERA FROM THE LATE TERTIARY OF THE NETHERLANDS EAST INDIES by L. W. LeRoy. *Colorado School of Mines Quarterly*, vol. 36, no. 1, 132 pp., 13 pls., 4 maps, photographs of faunal assemblages, and tables; $2.00. January 1941.

The publication of this compact, well documented volume fills a long recognized void in our knowledge of Tertiary Foraminifera. While many of the smaller Foraminifera living in the region of the East Indies are well known, published information on fossil species has heretofore been meager. Because frequent comparisons have been made between the Oligocene Foraminifera of the Gulf Coast region of the United States and the living Foraminifera of the East Indies, many specialists in the field of smaller Foraminifera will be particularly interested in making comparisons with the fossil Foraminifera of that region.

The volume is divided into three parts. Part one deals with small Foraminifera from the late Tertiary of the Sangkoelirang Bay Area, East Borneo, Nederlands East Indies. This part contains descriptions and figures of 151 species and varieties of smaller Foraminifera of which seven are described as new. It is alwo accompanied by four excellent photographs of various faunal assemblages present in the area. Of the three plates of species, the first has 110 figures, the second 125 figures, and the third 112 figures. While the plates give an impression of being rather crowded at first glance, the drawings are well done and the specific characters show clearly. The author considers the age of the material to be either uppermost Miocene or lower Pliocene.

Part two entitled "Small Foraminifera from the Late Tertiary of Siberoet Island, off the West Coast of Sumatra, Nederlands East Indies" contains pictures and descriptions of 128 species and varieties, of which nine are described as new. This part is accompanied by seven excellent plates, an index map, and four photographs of faunal assemblages. The author states that

> the fauna represents an assemblage that appears to have been widely distributed during middle and late Tertiary time over the Malay Archipelago.

Part three entitled "Some Small Foraminifera from the Type Locality of the Bantamien Substage, Bodjong Beds, Bamtam Residency, West Java, Nederlands East Indies" contains pictures and descriptions of 47 species and varieties, of which four are described as new. This part is accompanied by three excellent plates, a map, a photograph of the faunal assemblage, and a correlation chart of the sediments of West Java. The species figured are thought to be Pliocene or possibly Pleistocene in age.

HENRY V. HOWE

REVIEW OF THE PELYCOSAURIA by Alfred S. Romer and Llewelyn I. Price. *Geological Society of America, Special Paper*, no. 28, 535 pp., 46 pls., 71 figs., 1940.

In 1907, E. C. Case published a comprehensive revision of the pelycosaurs of North America.[1] Since that time, until the publication of the report under consideration, no paper bringing together the large amount of new material and new concepts of the group has appeared. The *Review of the Pelycosauria* is a very welcome contribution to the literature dealing with this interesting order of synapsid reptiles. The book should be of great service to paleontologists specifically interested in early reptilian history and in the development of mammals, and should find a place in the library of students of others branches of vertebrate paleontology and teachers of the subject. It is not merely a compilation of work previously done but includes descriptions of much new material, new methods of approach to problems of paloentological research, and a wealth of information on distribution and relationships of the pelycosaurs.

The report may be conveniently divided into two sections. The first treats successively methods of study, classification, collecting localities, geological and geographical distribution, general morphology, habits, and relationships. The second portion con-

[1] CASE, E. C., *1907*, Revision of the Pelycosauria of North America: *Carnegie Inst. Washington Publ.* no. 55, p. 176.

sists of systematic descriptions and tables of measurements. In the section on "methods," the authors have discussed at some length a "yardstick" for comparison of proportions of forms of divers size, using as a basis the average of the cross-sections of the dorsal and lumbar vertebrae, and deriving a linear unit of r $\frac{2}{3}$ for measurement of lengths of various parts of the skeleton. Although the method has received some criticism, it remains a usable technique for dealing with this difficult problem. In differentiation of species from the same locality on morphologic bases, the writers are conservative, but they consider that stratigraphical or geological separation in most cases forms a basis for the assumption of specific differences.

The order Pelycosauria is divided into three suborders, the Ophiacodontia, the Sphenacodontia, and the Edaphosauria, a more logical separation than has been made previously. Some space is devoted to a consideration of the origin of the order. Many students of the origin of the pelycosaurs have believed that the order arose from the captorhinomorph cotylosaurs, but there has been little information on the precise source. The writers suggest that the order probably arose from a subgroup of the captorhinomorphs containing such forms as *Protorothyris*. The possibility of polyphyletic origin is entertained. The therapsid reptiles, more advanced synapsids, are considered to have been derived from the sphenacodont pelycosaurs and much evidence is offered in support of this conclusion. An excellent section summarizes the data concerning collecting localities and the significance of the stratigraphical and geological distribution.

The chapter dealing with general pelycosaur morphology is particularly good, offering a full analysis of the characters of the order as a whole as well as considerations of the component skeletal elements of the suborders and genera. Included are discussions of various morphological problems upon which the pelycosaurs have particular bearing.

In the systematic section, a general account of the characters of each suborder and family is given and this is supplemented by a concise, but detailed, analysis of the genera and species. Forty-three pages of tables of measurements, a bibliography, and an index complete the paper.

The illustrations deserve special notice. In the plates, skulls and principal postcranial elements of the most important genera are figured. Each skull is illustrated in what is presumed to have been its original condition with distortion corrected and missing parts restored. On the opposite page is a line drawing of the skull on which the sutures are clearly shown and the elements labeled. By this technique, the utility of the plates is greatly enhanced. The text figures, in the section on general morphology, group homologous elements or divisions of the skeleton on a single page, making for ease of comparison.

The authors are to be commended for producing a book which is admirable from the standpoint of content, organization, style, and illustrative material. The work does not cover the field completely, for specimens obtained in the last few years from New Mexico by the University of California are not considered, and, of course, the specimens discovered since the paper went to press are not included. The wealth of material which is included makes this paper indispensable to students of Permo-Carboniferous faunas, early reptiles, and the origin of mammals.

EVERETT CLAIRE OLSON

THE MATERIAL BASIS OF EVOLUTION, by Richard Goldschmidt. 436 pages. Yale University Press, New Haven, 1940.

Paleontologists concerned with the mechanics of evolution are certain to be interested in Dr. Goldschmidt's, *The Material Basis of Evolution*. Goldschmidt, one of the leading contemporary geneticists, has assembled impressive evidence gathered from research in many fields of biology in support of his theory on the mechanics of evolution.

It is Dr. Goldschmidt's contention that the processes of microevolution (evolutionary processes observable within a human lifetime) cannot explain macroevolution (evolution on a geological time scale). Microevolution functions entirely within the species by minor, heritable, chance variations in the arrangement of the genes. The

accumulation of micromutations and the occupation of favorable ecological niches by preadapted mutants develops a series of geographic races within the species. These geographic variants are not incipient species—a conclusion which immediately invalidates the neo-Darwinian concept of the origin of species by gradual accumulation of minor mutants which bridge the gap between species.

Species and higher taxonomic categories, Goldschmidt concludes, originate in single macroevolutionary steps by a repatterning of chromosomes. A new genetic system is produced by successive repatterning of the chromosomes until an individual with a changed development is introduced. The mechanics of development, Goldschmidt contends, permit huge changes ("hopeful monsters") to develop in a single step. The major evolutionary steps, then, have been explosive in nature, followed by a series of orthogenetic perfections (evolutionary series) which can be explained by preadaptation.

The author's thesis is so thoroughly documented that a reader cannot fail to be impressed, but a paleontologist who reads Dr. Goldschmidt's book is likely to find the treatment of paleontological evidence in the problem of evolution rather inadequate. Goldschmidt feels that there has been insufficient time during the history of life for an accumulation of micromutations to explain the vast variety of organisms. A species which contains many geographic variants is old, not new, because "new" species have not been in existence long enough to develop a large series of geographic races. Thus it is impossible to trace one species into another through a geographic race. The paleontologist might ask if it would not be possible to trace the origin of this "new" species by a series of time, rather than geographic variations from one species into another. This question is not answered, and certainly could never be answered without access to many well-preserved specimens applicable to such a study. Such material would necessarily need to be collected from a series of stratigraphic horizons measured in extreme detail.

Especially significant is the extensive bibliography in the text.

As Goldschmidt demonstrates, it is only by the combined efforts of geneticists, zoologists, botanists, embryologists, paleontologists, and taxonomists that modern science can approximate a clear understanding of the problems of evolution. Goldschmidt's conclusions are strikingly similar to those arrived at independently by Schindewolf, the German paleontologist. *The Material Basis of Evolution* is an outstanding contribution to the study of evolution.

THOMAS G. ROBERTS

PALÄONTOLOGIE, ENTWICKLUNGSLEHRE UND GENETIK, by Otto H. Schindewolf, Borntraeger, v+108 pp., 34 text figs, 1936.

Modern biologists are still far from agreed on the ways of evolution. Different workers have been impressed by the evolutionary picture revealed by their research, only too often disregarding evidence afforded by other fields. Particularly striking are the lamarkian trend of paleontologic thought, in utter contradiction to evidence from genetics, and the lack of appreciation of "orthogenesis" by zoologists. Because of this confusion, evolution has been questioned by some on the basis of lack of agreement between the separate branches of learning. Various phenomena in evolution are not to be explained by the limited viewpoints of Lamark, Darwin, or DeVries. Consequently some evolutionists have gone so far as to deny derivation of the larger taxonomic groups from common sources, and have taken recourse to much mysticism.

Schindewolf, in his book *Paläontologie, Entwicklungslehre und Genetik* attempts to reconcile the recent findings of genetics and paleontology, and interprets the critical points of evolution in this new light. The following deductions about evolution are developed:

The general theme of evolution, that certain "types" have developed from other types, has not been invalidated. All such development (species to species, genus to genus, etc.) takes place by parallel lines. Not individuals, but an abstract basic "type" of a species, genus, or group of higher taxonomic rank, gives rise to a new species, genus, or group of higher taxonomic rank. This "type" is concretely shown only

in juveniles before the development of individual, specific, or generic characters respectively; ontogeny leads every individual into a blind alley. True ancestral stages are therefore realized only in the early ontogeny of the ancestral animals. The more generalized (younger) the ontogenetic stage of an organism at which new developmental trends set in, the more this organism will differ from the adult ancestor, and the greater will be the taxonomic rank of the new type. Our only criterion for evolutionary derivation is similarity of form in time and space. Change of types, by basic changes of organization, takes place by saltation. The new association of characters arises suddenly in early ontogenetic stages (law of "origin of types in the early ontogeny"). Transitional forms are absent, commonly impossible. The two related forms will be similar in some characters not affected by the change. Phylogeny falls into two stages, (1) a short phase of discontinuous explosive formation of types, and (2) a longer one of more gradual, orthogenetic modification. These may be called the "preadaptive" and "adaptive" phases. Lamarckism is entirely invalid. Darwinism cannot explain the preadaptive phase. The latter is understandable only as a consequence of drastic, undirected mutation. The type thus developed may migrate to an environment to which it is well fitted and may persist there. The "adaptive" phase is one of slight, commonly "directed," mutations, modified by Darwinistic selection. Orthogenesis is explainable on the basis of genetics. Development of life is dependent on environment not in any Lamarckian sense, but in the degree of mutability, and therefore the times of development of new types, are influenced by it. Beyond mutation as the final cause of evolution natural science cannot go. The irrational remainder cannot be solved by it.

Schindewolf's conclusions represent a critical evaluation and development of previous thought, and its combination into a clear system. Very striking is the extensive part dealing with proterogenesis, an illustration of the law of "development of types in the early ontogeny." In proterogenesis, the new type appears at an early stage, but is then overcome by the old type, so that the adult is not appreciably different from the ancestral form. The new type progressively pervades the following ontogenetic stages. Examples are drawn from the Foraminifera, nautiloids, ammonoids, and primates.

The book is written in clear cut and well organized style, and should be thoroughly familiar to everyone dealing with evolutionary problems.

ALFRED FISCHER

JOURNAL OF PALEONTOLOGY, VOL. 15, NO. 4, PP. 440–446, July, 1941

SOCIETY RECORDS AND ACTIVITIES

REPORTS AND MINUTES OF THE FIFTEENTH ANNUAL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The fifteenth annual meeting of the Society of Economic Paleontologists and Mineralogists was held in Houston, Texas, Wednesday to Friday, April 2–4, 1941. The meeting was held in conjunction with the annual meeting of the American Association of Petroleum Geologists.

Vice-president John R. Sandidge and secretary-treasurer H. B. Stenzel met with members of the executive committee of The American Association of Petroleum Geologists on Monday, March 31, to discuss editorial policy concerning both societies and to urge financial support for the *Journal of Paleontology*. These two items were brought before the Business Committee of The American Association of Petroleum Geologists in session Tuesday, April 1. The Business Committee voted to recommend to the executive committee that the association contribute $1,100.00 for 1941 to the Society of Economic Paleontologists and Mineralogists to facilitate adequate Publication of paleontological papers. The same committee also recommended to the executive committee that the association adopt as a policy that the editor should decline for publication in the Bulletin any description of fossils.

The council of the Society of Economic Paleontologists and Mineralogists held its annual meeting Thursday, April 3. Present were the following members of the council: president Carey Croneis, vice-president John R. Sandidge, and secretary-treasurer H. B. Stenzel. Present by invitation were: Henry V. Howe, Norman D. Newell, and W. H. Twenhofel. The following items came before the council meeting:

1. Special or honorary publication.
2. Results of election of officers.
3. Change in postage rates on foreign subscriptions.
4. Increase in the cost of publishing.
5. Significant items in the financial report.
6. Change in By-Laws. The council considered it advisable that the By-Laws be changed to lower the dues for members of the Society taking the *Journal of Paleontology* from $6.00 to $5.00.
7. Budgeting of funds for the printing of the *Journal of Sedimentary Petrology*. The council voted to allocate $1,000.00 for that Journal for the year 1941 subject to change by the secretary-treasurer in case of an emergency.
8. Description of species. The council voted upon an editorial policy to cover the description of fossils and empowered the editor to publish the resolution in the *Journal of Paleontology*.
9. Drive for new members in the line of sedimentary petrology.
10. Advertising in the two Journals. The council voted to accept advertising in the *Journal of Sedimentary Petrology* and to appoint two committees for the securing of advertising in the two journals.

The regular program of the Society began at 9:30 A.M., Wednesday, April 2. The following papers were presented:

NORMAN D. NEWELL and BERNARD KUMMEL, "Permian-Triassic relations in the Middle Rockies."

NORMAN D. NEWELL, "Myalinidae in zonation of the Late Paleozoic."

ALFRED G. FISCHER, "Preliminary studies of the Phosphoria formation."

HUGH FRENZEL and MAURICE MUNDORF, "Fusulinidae from the Phosphoria in Montana."

HAROLD B. RENFRO, "Faunal correlation of the Satanka and Lykins formations."

J. HARLAN JOHNSON, "The calcareous algae during Permian time."

J. HARLAN JOHNSON and M. E. DORR, "Permian algal genus *Mizzia*."

CHARLES B. READ, "Sequence and relationships of Late Paleozoic floras of the southwestern United States."

CHARLES B. READ, "Pennsylvanian formations and floral zones in the central and northern Appalachian region."

BERNHARD KUMMEL, JR., "New Eo-triassic cephalopod zone in Idaho." (By title)

EDWARD A. FREDERICKSON, "Cambrian-Ordovician boundary in Oklahoma."

CHARLES E. DECKER. "Cambrian graptolites from the Wilberns formation of Texas."

CHARLES E. DECKER, "An extensiform *Didymograptus-Tetragraptus* horizon in Oklahoma."

CHARLES E. DECKER, "A profusely branched Ordovician hydrozoan in Oklahoma."

FRANK V. STEVENSON, "The Devonian Sly Gap formation of New Mexico."

THOMAS G. ROBERTS, "Geographic variation in *Triticites ventricosus*."

HENRY V. HOWE, "Use of soap in the preparation of samples for micropaleontologic study."

W. H. TWENHOFEL, "The sediments of Little Long lake, Wisconsin."

S. W. LOWMAN, "Ecologic relationships of some brackish water and shallow marine Foraminifera of Louisiana."

FRANK E. LOZO, "Biostratigraphic studies of some Texas Comanchean Foraminifera."

BENJAMIN H. BURMA, "Jurassic unconformities in eastern Wyoming and western South Dakota." (By title)

BENJAMIN H. BURMA, "Observations on the ontogeny of fusulinids." (By title)

RAYMOND E. PECK, "Comatulid crinoids from the lower Cretaceous of Texas." (By title)

On Thursday morning, April 3, the S.E.P.M. met in a joint session with the A.A.P.G. CAREY CRONEIS, S.E.P.M. President, delivered his presidential address on "Micropaleontology—past and future."

The following papers were presented on Friday, April 4.

A. R. MORNHINVEG, "The Foraminifera of the Red Bluff."

HENRY V. HOWE, "Fauna of the Oligocene Glendon formation at its type locality."

FRED E. SMITH, "Micropaleontology of two wells on the Fort Morgan Military Reservation, Baldwin County, Alabama."

J. A. CUSHMAN, "Some suggestions for ecologic studies of the Foraminifera."

JULIA GARDNER, "Correlation of the lower Claiborne in the Gulf Province."

R. W. HARRIS, "Ostracoda from the subsurface Simpson of the North Texas-Fort Worth Syncline."

R. W. HARRIS and W. H. THAMS, "Simpson Ostracoda of the Cumberland area of southern Oklahoma."

RAYMOND C. MOORE and HARRELL L. STRIMPLE, "A new blastoid from upper middle Pennsylvanian rocks of Oklahoma."

RAYMOND C. MOORE and LOWELL R. LAUDON, "Symbols for crinoid parts."

RAYMOND C. MOORE, "Erroneous emendation of generic names."

RAYMOND C. MOORE and HARRELL L. STRIMPLE, "Tegminal structure of the crinoid genus *Delocrinus*."

RAYMOND C. MOORE and RUSSELL M. JEFFORDS, "Studies on Permian corals."

ALFRED R. LOEBLICH, "Some Bryozoa from the Ordovician Bromide formation."

ALFRED R. LOEBLICH and HELEN TAPPAN, "Palmate Lagenidae from the lower Cretaceous and Washita group."

The program session was adjourned at 11:00 A.M., Friday, April 4, and the Society went into the annual business session, President Croneis in the chair.

The minutes of the 1940 meeting were approved as published in the July, 1940, *Journal of Paleontology*.

The following reports were given:

1. *Research Committee Report.*—W. H. Twenhofel, chairman.

The Research Committee held a meeting in Austin at the time of the annual convocation of the Geological Society of America. At that time it was agreed that Marcus A. Hanna prepare a paper for the *Journal of Paleontology* which would indicate sections in the fields of paleontology or stratigraphy where research was needed or desired, and W. H. Twenhofel be appointed to do the same for sedimentary mineralogy and petrology and to publish his paper in the *Journal of Sedimentary Petrology*. The two papers are essentially completed and it is expected they will appear in the respective journals during the current year.

At the same meeting it was considered that it might be desirable to prepare (1) a catalogue of type sections of stratigraphic units in the Gulf Coast region with brief descriptions of the sections, and (2), so far as possible, statements giving present extents of the exposures, and (3) a catalogue of type fossils found in the Gulf Coast region with information as to where these fossils are preserved and from what regions and localities they were collected. The committee held a second meeting at 3:00 P.M. on Thursday, April 3, in Houston. Present at

this meeting were J. B. Garrett, F. B. Plummer, S. G. Wissler, W. H. Twenhofel, and H. B. Stenzel (representing E. H. Sellards), and, by invitation, Carey Croneis, Gayle Scott, and M. A. Hanna. At this meeting it was decided to proceed with the two projects which had been considered at the Austin meeting. F. B. Plummer and H. B. Stenzel were appointed to undertake the preparation of catalogues of type sections of stratigraphic units in the Gulf Coast region, and Carey Croneis was appointed chairman of a committee with authority to appoint other members of the committee to prepare a catalogue of type fossils found in the Gulf Coast region, and ultimately all North America, together with information as to where these fossils are preserved, whether they are any longer in existence, and from what horizons and localities they were collected.

2. *Report of the Editor of the Journal of Sedimentary Petrology.*—W. H. Twenhofel again pointed out that too many articles were submitted by authors who were not members of the Society or subscribers to the *Journal* and stated that S.E.P.M. members should be its chief contributors. He called attention to the fact that 30% of references and citations to sedimentation are from the *Journal of Sedimentary Petrology*. He appealed to members to prepare articles on chemistry, physics, and mineralogy which would be of value to workers in the field of sedimentation.

3. *Report of the Editor of the Journal of Paleontology.*—Norman D. Newell reported that during the past year 283 pages of paleontological literature, including 26 plates and 55 text figures, were published by the Society. As heretofore, attempt has been made to publish manuscripts in the order of their acceptance, with occasional exceptions. However, in order to facilitate maintenance of the necessary balance between plates and text figures, certain manuscripts have been published out of the normal chronologic order. This situation has been somewhat aggravated by the need for restricting recent issues to a minimum size.

During the coming year, it will be possible to increase the size of our issues, and, therefore, publish papers approximately in the order of their acceptance.

4. The Society expressed its thanks to the University of Wisconsin for contributions during the year in connection with the editing of the two Journals.

5. *Report of the Secretary-Treasurer.*—H. B. Stenzel read the following records:

FINANCIAL STATEMENT, DIVISION OF PALEONTOLOGY AND MINERALOGY, FOR YEAR 1940

To the Council,
Society of Economic Paleontologists and Mineralogists,
Tulsa, Oklahoma.

DEAR SIRS:

In continuation of our examinations in prior years we have examined the accounting records of the Society of Economic Paleontologists and Mineralogists for the year ended December 31, 1940, and now submit our report together with the following statements:

Exhibit	
A	Statement of Financial Condition, December 31, 1940
B	Statement of Income for the year ended December 31, 1940
Schedule	
1	Statement of Receipts and Disbursements for the year ended December 31, 1940

In connection with our examination, we reviewed the system of internal control and the accounting procedures of the Society and, without making a detailed audit of the transactions, examined or tested accounting records of the Society and other supporting evidence, by methods and to the extent we deemed appropriate.

Demand and savings deposits were reconciled to certificates received directly from the depositories. Inventory of publications represents approximately 26,500 *Journals* (exclusive of *Journals* in excess of complete sets for issues prior to 1940) as shown by the records, including certain issues printed at the expense of the Paleontological Society for the years 1935 to 1940, inclusive, stated at appraised values of fifty cents each for *Journals* printed prior to 1940 or cost to either the Society of Economic Paleontologists and Mineralogists or the Paleontological Society for *Journals* printed in 1940. We made extensive tests of inventory quantities and computations.

The Society of Economic Paleontologists and Mineralogists has agreed to distribute a portion of its income to the Paleontological Society. Income accruing to the Paleontological Society for the year 1940 amounted to $313.64.

In our opinion, the accompanying statement of financial condition and related statement of income present fairly the position of the Society of Economic Paleontologists and Mineralogists at December 31, 1940, and the results of its operations for the year, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed) ARTHUR YOUNG & COMPANY, *Accountants and Auditors*
TULSA, OKLAHOMA
February 6, 1941

EXHIBIT A
STATEMENT OF FINANCIAL CONDITION
DECEMBER 31, 1940

ASSETS

CURRENT ASSETS:		
Demand deposits—		
The First National Bank and Trust Company, Tulsa, Oklahoma	$ 4,543.94	
National Bank of Commerce, Tulsa, Oklahoma	161.11	$ 4,705.05
Savings deposit—		
The First National Bank and Trust Company, Tulsa, Oklahoma		1,045.40
Accounts receivable—		
Printed matter	$ 96.80	
Advertising	41.23	138.03
Inventory of publications—see report		13,723.84
TOTAL CURRENT ASSETS		$19,621.32
FURNITURE AND FIXTURES	$ 482.60	
Less: Reserve for depreciation	144.20	338.40
PREPAID AND DEFERRED CHARGES		627.16
TOTAL ASSETS		$20,586.88

LIABILITIES AND SURPLUS

CURRENT LIABILITIES:		
Accounts payable		$ 500.89
Accrued printer's charges		627.16
Amount due to Paleontological Society		313.64
TOTAL CURRENT LIABILITIES		$ 1,441.69
DEFERRED INCOME:		
Subscriptions to Journals	$ 1,081.40	
Membership dues for 1941	767.00	1,848.40
SURPLUS:		
Balance, December 31, 1939	$17,052.74	
Net income for the year ended December 31, 1940—Exhibit B	244.05	
Balance, December 31, 1940		$17,296.79
CONTINGENT LIABILITIES:		
All known liabilities of the Society at December 31, 1940, were recorded in the accounts and no litigation was pending at that date.		
TOTAL LIABILITIES AND SURPLUS		$20,586.88

SUBJECT TO COMMENTS IN ACCOMPANYING REPORT

EXHIBIT B
STATEMENT OF INCOME FOR THE YEAR ENDED
DECEMBER 31, 1940

INCOME:		
Dues and subscriptions—		
Journal of Paleontology and *Sedimentary Petrology*	$ 800.00	
Journal of Paleontology	2,906.63	
Journal of Sedimentary Petrology	875.67	$ 4,582.30
Sales of back numbers—		
Journal of Paleontology	$ 1,072.20	
Journal of Sedimentary Petrology	197.52	1,269.72
Sales of plates and reprints		219.01
Advertising		62.46

Interest on savings deposit			$ 10.47
Recovery of accounts previously charged off			58.26
Other income			41.53
TOTAL INCOME			$ 6,243.75
Less: Proportion of income accrued to Paleontological Society			313.64
			$ 5,930.11
COSTS AND EXPENSES:			
Printing expenses—			
Journal of Paleontology	$2,673.17		
Journal of Sedimentary Petrology	1.067.23	$ 3,740.40	
Postage and mailing		421.46	
Office rent		300.00	
Clerical salaries		700.00	
Audit expense		100.00	
Office supplies and expenses		143.32	
Depreciation		48.26	
Bad debts		29.37	
Other costs and expenses		158.35	
		$ 5,641.16	
Decrease in inventory of publications		44.90	5,686.06
NET INCOME			$ 244.05

SUBJECT TO COMMENTS IN ACCOMPANYING REPORT

SCHEDULE 1
STATEMENT OF RECEIPTS AND DISBURSEMENTS
FOR THE YEAR ENDED DECEMBER 31, 1940

DEMAND DEPOSITS, DECEMBER 31, 1939			$ 4,250.40
RECEIPTS:			
Membership dues and subscriptions—			
Year 1940—			
Journals of Paleontology and *Sedimentary Petrology*	$ 510.46		
Journal of Paleontology	1,713.72		
Journal of Sedimentary Petrology	493.27	$ 2,717.45	
Year 1941—			
Journal sof Paleontology and *Sedimentary Petrology*	$ 352.00		
Journal of Paleontology	1,078.00		
Journal of Sedimentary Petrology	311.80	1,741.80	
Accounts receivable		508.11	
Sales of back numbers—			
Journal of Paleontology	$ 765.20		
Journal of Sedimentary Petrology	114.80	880.00	
Sales of plates		189.94	
Miscellaneous		352.72	6,390.02
			$10,640.42
DISBURSEMENTS:			
Printing expenses—			
Journal of Paleontology	$1,970.45		
Journal of Sedimentary Petrology	626.51		
Engraving *Journal of Paleontology*	598.46	$ 3,195.42	
Accounts payable		292.15	
Payment to Paleontological Society		395.23	
Editorial salaries		300.00	
Clerical salaries		700.00	
Audit expense		100.00	

Office supplies and expenses	$ 65.52	
Postage and mailing	297.59	
Office rent	300.00	
Refunds on subscriptions	56.48	
Miscellaneous	232.98	5,935.37
DEMAND DEPOSITS, DECEMBER 31, 1940		$ 4,705.05

SUBJECT TO COMMENTS IN ACCOMPANYING REPORT

BACK VOLUME SALES

Back volumes of the *Journal of Paleontology*	$839.60
Back volumes of the *Journal of Sedimentary Petrology*	$169.93

PRINTING AND ENGRAVING BILLS FOR 1940

JOURNAL OF PALEONTOLOGY

	Banta Printing Bills	*Meriden Engraving Bills*	*Total Printing and Engraving Bills*	*S.E.P.M. Total Printing and Engraving Bills*
Number 1 (January)*	$ 557.06	$ 236.18	$ 793.24	
Number 2 (March)	593.81	224.23	818.04	$ 818.04
Number 3 (May)*	731.35	237.31	968.66	
Number 4 (July)	684.12	195.06	879.18	879.18
Number 5 (September)*	877.17	250.61	1,127.78	
Number 6 (November	692.52	179.17	871.69	871.69
	$4,136.03	$1,322.56	$5,458.59	$ 2,568.91
(1939 Totals)	($4,399.57)	($1,404.42)	($5,803.99)	($ 2,674.84)

* Odd numbers paid for by Paleontological Society.

JOURNAL OF SEDIMENTARY PETROLOGY

	Banta Printing Bills
Number 1 (April)	$ 285.82
Number 2 (August)	340.69
Number 3 (December)	382.20
	$1,008.71
(1939 Total)	($ 848.70)

MEMBERSHIP, MAILING, AND JOURNAL STATISTICS

	March 1941	*March 1940*	*March 1939*
1. S.E.P.M. Membership:			
Active Members	254	239	234
Associate Members	81	79	79
Total	335	318	313
2. *Journal of Paleontology* Mailing List:			
S.E.P.M. Active Members	220	214	201
S.E.P.M. Associate Members	52	50	52
S.E.P.M. Subscribers	272	280	340
P.S. Members	341	370	345
Total	885	914	938
3. *Journal of Sedimentary Petrology* Mailing List:			
S.E.P.M. Active Members	118	109	108
S.E.P.M. Associate Members	20	19	19
S.E.P.M. Subscribers	242	262	260
Total	380	390	387

4. Number of pages in 1940 *Journal of Paleontology*	615 (632, 1939)
5. Number of plates in 1940 *Journal of Paleontology*	69 (69, 1939)
6. Total edition of 1940 *Journal of Paleontology*	1,300 (1,300, 1939)
7. Number of pages in 1940 *Journal of Sedimentary Petrology*	149 (136, 1939)
8. Total edition of 1940 *Journal of Sedimentary Petrology*	500 (500, 1939)
New members from March 1, 1940, to March 1, 1941 (March 1, 1939, to March 1, 1940,—9)	16
New associates from March 1, 1940, to March 1, 1941 (March 1, 1939, to March 1, 1940,—11)	16
Transfers to active membership from March 1, 1940, to March 1, 1941 (March 1, 1939, to March 1, 1940,—12)	7

It was moved, seconded, and carried that all reports be accepted.

The Society expressed its very sincere thanks and commendation for the splendid work the secretary had accomplished during the year.

6. *Report of the Resolutions Committee.*—"Be it resolved that the Society of Economic Paleontologists and Mineralogists expresses its appreciation and sincere thanks to The American Association of Petroleum Geologists and the Houston Geological Society for their efforts in making the annual meeting at Houston such an outstanding success."

7. *Discussion of dues for 1942.*—It was considered appropriate to lower S.E.P.M. dues for those who take the *Journal of Paleontology* only. It was moved, seconded, and carried that the dues for members of the S.E.P.M. taking the *Journal of Paleontology* be $5.00 beginning with January 1, 1942.

8. *A.A.P.G. Grant.*—It was moved, seconded, and carried that secretary-treasurer Stenzel be given a vote of thanks for his valued efforts in obtaining the grant of $1,100.00 from The American Association of Petroleum Geologists. It was pointed out that this grant was approved by the Association largely because of his persistence and arguments.

9. *Special publication.*—It was moved, seconded, and carried that the matter of a special publication be left to the judgment of the council.

Carey Croneis expressed the thanks of the Society to the Houston Geological Society and to Marcus A. Hanna, chairman of the S.E.P.M. technical program, for the success of the meeting.

10. The results of the election of officers by mailed ballot, for the new year ending in April, 1942, were announced by secretary Stenzel. The new officers were introduced and each expressed appreciation of election.

President: Henry V. Howe
Vice-President: Alva C. Ellisor
Secretary-Treasurer: H. B. Stenzel

The meeting adjourned at 12:00 Noon Friday, April 4, 1941.

Verlag von Gebrüder Borntraeger in Berlin W 35 Deutschland

Fortschritte der Paläontologie. prepared under direction of O. H. Schindewolf, Berlin, with aid of numerous specialists. Vol. 1—Review of the years 1935-1936, contains 384 pp., 2 figs. Price, RM 29.60; Vol. 2—Review of the years 1937-1938, contains 402 pp. Price, RM 31.20.

Fortschritte der Paläontologie is intended to be a biennial publication indicating significant advances in paleozoology and paleobotany by means of critical summaries and discussion of the most important works issued in successive two-year periods. The first two volumes, now available, cover literature of 1935 to 1938, and provide a comprehensive view of the present status of paleontological research.

Paläontologie, Entwicklungs- und Vererbungslehre (Paleontology, Evolutionism and Genetics) by O. H. Schindewolf; contains 108 pages, 34 text figures; published 1936. Price, RM 5.20.

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Secretary-Treasurer, H. B. Stenzel, Austin, Texas.

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Association Headquarters, 708 Wright Bldg., Tulsa, Okla.

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